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RESEARCH REVIEW

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The RESEARCH REVIEW is a quarterly supplement published by TRAFFIC SAFETY for the reporting of research that relates to traffic safety. This service is designed to provide those who conduct research, and/or utilize research findings, information that contributes to, advances, or clarifies the body of traffic safety knowledge. The value of research and the prevention of duplication and overlap is enhanced by prompt reporting. To fulfill this purpose, the RESEARCH REVIEW will present completed reports, abstracts, summaries of research in progress, and information regarding contemplated research.

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Manuscripts appropriate for publication should be submitted to the Research Division of the National Safety Council, 425 North Michigan Ave., Chicago 11. Manuscripts cannot be returned unless accompanied by a self-addressed, stamped envelope. Editorial handling will be easier if manuscripts are typed, double-spaced in triplicate, and accompanied by an abstract of 200 words or less and all original art work. Any other information regarding research in progress or contemplated research can be submitted in any form that outlines the full particulars, i.e., investigator, problem, hypotheses, methodology, desired or expected outcomes, etc.

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. . . give me commentators plain,

RESEARCH BRIEFS

Articles in This Issue

Dr. William Haddon, Jr., and his co-investigator Dr. Victoria A. Braddess in their report "Alcohol in the Single Vehicle Fatal Accident" found that the use of alcohol was probably a causal factor in one-half or more of the deaths of all of the drivers they studied who were killed in accidents involving neither other vehicles nor pedestrians. From a group of 117 drivers so involved, post-mortem determinations for alcohol were performed on 83 cases. The article presents some concisely tabulated data, gives an excellent review of previous research and a résumé of medicolegal interpretations of blood alcohol levels. The investigators rigorously followed precise scientific procedures in arriving at their conclusions, and many significant implications are pointed out that should prove of value to scientific investigators and lay administrators in the field of traffic safety. The investigators quote Heise as stating in 1934 "that the problem of controlling the drinking driver and pedestrian is far from being solved may be due, in part, to the fact that no accurate statistics are available regarding the relationship of alcohol to automobile accidents. . . ." This study of Haddon and Bradess is a very positive forward step in answering this comment.

Fletcher N. Platt in Part 3 of his "Operations Analysis of Traffic Safety" has brought to fruition the promise shown in his previous two reports. He has developed some logical procedures for selecting fundamental goals and for determining measures of effectiveness to be used for the evaluation of the traffic safety problem. He also establishes a basis for highlighting research needs, and he suggests methods and techniques that might be useful. Mr. Platt has codified and given body, substance and order to a heretofore relatively amorphous body of knowledge. His broad, yet solid, grasp of a diversity of subjects is clearly apparent. In all, Mr. Platt has furnished to future investigators not only a framework within which to operate, but also a challenge to build on the foundation which he has established and to further interrelate the many areas where he has demonstrated that relationships exist.

Another part of B. J. Campbell's study of the point system appears in this issue. Herein Mr. Campbell, through the use of control and experimental groups, arrives at conclusions regarding the effects of driver improvement actions on driving behavior. He found, for example, that far fewer drivers placed under suspension violated subsequently than did drivers in his control group; also, that drivers placed on probation showed a better subsequent record than those suspended. Fewer drivers given short suspensions violated subsequently than was the case with those given long suspensions. He concludes that driver improvement justifies its existence by clear demonstration of its ability to influence drivers' behavior. Mr. Campbell makes excellent use of the statistical method in presenting his evidence and treating his data. Investigators, administrators and enforcement officials should gain from Mr. Campbell's presentation.

Errata

In Oscar W. Richards' article "Night Driving Seeing Problems," which appeared in the June issue of the *Research Review*, on page 26 under Efforts to See Increase Fatigue, the word "sub-optional" should have been "sub-optimal." Also, in the list of references, no. 41, the name "Lloyd" should have appeared as "Floyd."

Survey of Research

Some months ago the Research Division made a survey of research that might be accomplished if financial support were available. A total of 72 projects was reported, and the funds needed to carry out these projects amounted to approximately $2,000,000. In many of the cases, suggestions were made to the investigators as to how and where financing could be obtained. We are happy to report that some of these projects have since gained the necessary support and are now underway. The entire list of projects was turned over to a special committee of the Highway Research Board on research needs for its use in determining research priorities on a national level.

Fellowships

The Research Division receives frequent requests for information regarding the availability of fellowships for graduate study in the field of traffic safety, engineering, enforcement, etc. At present we are gathering material in anticipation of publishing at some future date a comprehensive report on the subject.

Publications

In the Journal of the American Medical Association, volume 169, number 11, March 14, 1959, the Committee on Medical Aspects of Automobile Injuries and Deaths presents its recommendations under the title of "Medical Guide for Physicians in Determining Fitness to Drive a Motor Vehicle." This is a summary of the pertinent medi-

. . . who with no deep researches vex the brain

—G. Crabbe (1754—1832)

cal data presently available concerning the ability of an individual to operate a motor vehicle. It is believed that a conscientious medical evaluation of the individual's fitness to drive, with appropriate follow-up, can reduce motor vehicle accidents very significantly.

The Center for Safety Education at New York University has recently published a booklet entitled "Basic Aspects and Applications of the Psychology of Safety." The booklet is composed of two articles, one by Dr. Flanders Dunbar entitled "Accidents and Life Experience" and the other by Dr. Leon Brody entitled "Accidents and 'Attitudes'." The two authors, both of whom have achieved eminence in the field of safety, have condensed a tremendous amount of knowledge and information into this 24-page pamphlet. Both articles contain a great many implications for the educator and the industrialist. There are also many practical and sound suggestions which will be found useful for anyone in the field of safety. It can be purchased from NYU for fifty cents; quantities of 20 or more are forty cents each.

A recent study entitled "Effectiveness of Symbols for Lane Control Signals" by T. W. Forbes, Edward Gervais and Terrence Allen of Michigan State University presents an excellently designed study for determining the effectiveness of various types of traffic signals. The investigators concern themselves mainly with red, green and amber bullseye signals, slashed arrows, arrows up and down, and "x's." Their findings should be of interest and value to traffic engineers. This study was presented at the Highway Research Board annual meeting in Washington, D. C., on January 29.

For those investigators in the field of safety research who are not already familiar with them, the editor strongly recommends the newsletters published each month by Michigan State University and New York University. A great deal of up-to-the-minute information is presented in both of these newsletters, bibliographies and new publications are mentioned, course listings and opportunities for fellowships and scholarships are also presented. These newsletters can be obtained by writing directly to the universities concerned.

The National Education Association, 1201 Sixteenth St., N.W., Washington 6, D. C., has prepared a publication entitled "Careers in Highway Traffic Safety." This publication may be ordered for $1.00 from NEA. For individuals preparing to do advanced work in the field of traffic safety or for students who are contemplating entering this field the booklet should prove quite useful and valuable.

The National Association of Automotive Mutual Insurance Companies has, as a public service, published its fourth edition of "Here's How!" This 100-page booklet is crammed full of traffic safety project ideas and concerns itself with all aspects of safety, not just traffic safety alone. Such a booklet should find great use with local safety councils, teachers in driver education, and public and civic organizations which engage in safety projects. The booklet can be obtained free of charge by writing directly to the National Association of Automotive Mutual Insurance Companies, 20 N. Wacker Drive, Chicago, Illinois.

THE AUTHORS

William Haddon, Jr.

Dr. William Haddon, Jr. is Director of the Driver Research Center of the New York State Department of Health and the State Bureau of Motor Vehicles. He received his S.B. from M.I.T., his M.D. from Harvard Medical School, and his Master of Public Health (magna cum laude) from Harvard School of Public Health. As an epidemiologist his work on motor vehicle accidents reflects his broader concern with the impacts of modern technology on the health of individuals and communities. He is especially interested in the problems of interdisciplinary research management in the medical, engineering and public health areas.

Victoria A. Bradess

Dr. Victoria A. Bradess, an alumna of Barnard College, received her M.D. from New York Medical College. A Diplomate of the American Board of Pathology she is Director of the County Laboratory and Division of Pathology of Grasslands Hospital, and is Chief Medical Examiner of the County of Westchester.

Fletcher N. Platt

Fletcher N. Platt has been associated with the Ford Motor Co. since 1950. He assumed his present position, manager of the Traffic Safety and Highway Improvement Department of the Public Relations and Advertising staff, in 1954.

He was born in Philadelphia in 1917 and was graduated in 1938 from the University of Michigan with a B.S. in Aeronautical Engineering. Before joining Ford, he was associated with Chance Vought Aircraft, Kaiser Cargo, Inc. and the Rheem Manufacturing Co. He is a member of the Institute of Traffic Engineers, Institute of Aeronautical Sciences and Society of Automotive Engineers.

B. J. Campbell

B. J. Campbell is completing his Ph.D. in experimental psychology at the University of North Carolina where he is also an Assistant Director of the Institute of Government. As an undergraduate he specialized in psychology and physics, and as a graduate, in behavior theory, sensory psychology and learning theory. He is a member of Sigma Xi and Psi Chi.

His traffic safety research includes direction of the point system study for the AAMVA. During September he will join the staff of Cornell's Automotive Crash Injury Research as Administrator of Research. His wife and unofficial research partner, is completing her Ph.D. in clinical psychology.

ALCOHOL IN THE SINGLE VEHICLE FATAL ACCIDENT

by William Haddon, Jr. and Victoria A. Bradess

Records of motor vehicle accidents occurring over an eight-year period were used for the identification of all drivers killed in accidents involving neither other vehicles nor pedestrians. The resulting group of 117 drivers included 87 who died within four hours of their accidents. Postmortem determinations for alcohol were performed in 83 (95%) of these 87 cases. Of these 83, forty-one (49%) were found to have had blood alcohol levels of 0.15% or more at death; and an additional 17 (20%) were found to have levels between 0.05 and 0.15%. There is justification for assuming that any driver with a blood alcohol level of 0.15% or more is incapable of driving safely and that this is also true of many drivers with levels in the 0.05 to 0.15% range. It is therefore concluded that the use of alcohol was probably a causal factor in one half or more of the deaths which resulted from accidents of this type.

Estimates of the frequency of markedly elevated blood alcohol levels among those involved in motor vehicle accidents have ranged from 10 to 80%.[1] It is the purpose of this paper to report the findings of an exploratory investigation designed to quantitate more precisely this factor in a specific group of fatalities occurring in one area and to suggest that similar groups may prove useful for statistical purposes.

Most reports of the frequencies of such postmortem alcohol levels, a number of which have recently been summarized by Plymat,[2] have come from police and related sources. In general, with relatively few exceptions, these have failed both to reach the available scientific literature and to be presented in a sufficiently documented form to permit their complete evaluation from the scientific standpoint. Their value, as a result, is difficult to assess. Taken as a group, however, one or more of a number of substantial shortcomings appear to have been present in many instances. Foremost among these has been the frequent study of only relatively small fractions of the groups of fatalities whose characteristics these fractions were assumed to represent. Furthermore, it has been a not uncommon practice to group the persons killed without reference to their individual responsibilities for the collisions in which they were involved. In addition, some investigators have studied subjects who have died as long as 24 hours after the time of the accident, a procedure which has undoubtedly resulted in the inclusion of some whose original blood alcohol levels had undergone substantial metabolic lowering in the relatively long interval prior to death. Finally, information has often been omitted both as to the biological materials on which the determinations were based and as to the circumstances of their collection.

In order to avoid these and related deficiencies, the retrospective and exploratory investigation reported here sought, as its primary objective, to determine the levels of alcohol present in the blood of a carefully studied group of drivers, those whose fatal accidents had involved neither pedestrians nor vehicles other than their own and who had survived for not more than a given short period after the event.

Case Material

The group which provided the subdivision used consisted of all motor vehicle fatalities which had occurred in Westchester County from Jan. 1, 1950, through Dec. 31, 1957. To assure completeness, the files of the Office of Vital Statistics in the New York State Department of Health were used to identify all deaths due to motor vehicle accidents in Westchester County during that period. The resultant lists were matched with those of the Office of the Medical Examiner. Of the 626 cases identified in this fashion, 37 were excluded. These consisted of 20 driveway and other off-highway motor vehicle fatalities and

TABLE 1.—*Classification of Motor Vehicle Fatalities by Age of Person and Type of Specimen Used for Alcohol Level Determination, Westchester County, New York, 1950-1957*

Class of Fatality	Total All Ages	Age 16 Years and Over					
			With Alcohol Level Determination		Specimen Used		
		Total	No.	%	Blood	Brain	Liver
Drivers	208	208	160	77	124	7	29
Single motor vehicle ...	117	117	95	81	76	4	15
More than one motor vehicle ...	84	84	58	69	44	3	11
Other and not specified	7	7	7	*	4	...	3
Passengers ..	197	184	107	58	97	1	9
Pedestrians .	177	136	78	57	60	4	14
Others	7	1	0	*	...	...	...
Total	589	529	345	65	281	12	52

*Percentages based on less than 10 observations are not indicated.

From the Driver Research Center of the New York State Department of Health and the New York State Bureau of Motor Vehicles, and the Office of the Medical Examiner, Westchester County.

Read in the Session on Traffic Accidents before the Section on Miscellaneous Topics at the 107th Annual Meeting of the American Medical Association, San Francisco, June 25, 1958.

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17 borderline cases which, though they had occurred upon public roads more or less in association with motor vehicles, were not considered appropriate for inclusion. Illustrative of the latter group were such cases as those of a single pedestrian suicide and of two persons who fell after alighting from unmoving vehicles. The remaining 589 fatalities formed the basis of the present study.

Westchester, a wealthy county of 435 square miles located immediately north of New York City, includes urban, suburban, and semirural areas. According to the 1957 special census its population was 752,406, an increase of 126,590 over 1950. Although data are not available as to the number of residents holding driver's licenses, registrations of vehicles of all types are known to have increased during the same period from 213,000 to 308,000. No appreciable information was available either as to the number of miles driven within the county or as to the ways in which vehicles were used, although it is known that much of the traffic load is produced by nonresidents.

Alcohol Determinations

Of the 589 fatally injured persons, 345 (65%) had had alcohol determinations (table 1). Two hundred eighty-one of these were based on blood, 12 on brain, and 52 on liver specimens. These determinations were made with a modification of the Jetter method,[3] a procedure which measures volatile reducing substances, here taken as ethanol. Blood specimens consisted of heart blood drawn at autopsy, in almost all cases prior to the severance of the great vessels. No femoral or other peripheral blood specimens were used. In the several instances in which brain and liver alcohol levels were determined, parenchymal tissue was used. The values given for all specimens are the results of the laboratory determinations, although it is known that brain and liver alcohol levels tend to be substantially lower than the simultaneous blood concentrations.[4] For this reason, the group of liver and brain alcohol values given here may be regarded as a conservative estimate of the blood alcohol levels to which they corresponded.

As noted, postmortem alcohol determinations had been carried out in only a fraction of cases, and only rarely among those under 16 years of age. However, even when limited to those 16 years of age and over, determinations were found to have been performed in the latter group least often for pedestrians (57%) and passengers (58%) and most often for drivers (77%). As a result of the relatively large percentages of these groups lacking determinations, it was not felt that estimates of the distributions of alcohol levels among their numbers could be made without further subdivision.

Results

The total group of 589 motor vehicle fatalities was first analyzed in order to determine whether or not there had been any significant changes over the eight years represented. The variations in the total number of fatalities from year to year proved not to be statistically significant ($p>0.10$). In addition, the variations from year to year by type of accident, class of vehicle involved, class of fatality, and age or sex of the deceased all proved to be not statistically significant ($p>0.10$).

The data for the eight-year period were therefore combined and treated as a single group. When handled in this fashion, there was no statistical significance in the variation in the number of fatalities from month to month ($p>0.70$). However, as anticipated from many prior reports, many more fatalities occurred during the two and one-half day period between 5 p. m. Friday and 5 a. m. Monday than during the remainder of the week. This is seen in the fact that 277 (48%) of the 573 fatalities for which complete information was available with regard to time and day of accident fell in this 60-hour week-end period. In addition, when distributed by time of day, it was found that 63% of the 573 fatalities resulted from accidents which occurred between 5 p. m. and 5 a. m.

TABLE 2.—*Blood Alcohol Level and Interval Between Accident and Death for Fatally Injured Persons Sixteen Years of Age and Over, with Blood Alcohol Level Determinations, Westchester County, New York, 1950-1957*

Alcohol Level, % by Weight	Total	Internal Between Accident and Death, Hr.			
		<4	4-11	>11	Not Specified
Negative	147	117	21	9	...
0.01-0.04	13	10	2	1	...
0.05-0.09	23	19	3	...	1
0.10-0.14	15	15	...	...	...
>0.14	83	79	3	...	1
Total	281	240	29	10	2

As has been noted, alcohol levels were not determined for all fatally injured persons. Since the minimum licensing age in New York is 16, and since alcohol determinations were rarely carried out on children, the data given in tables 2 and 3 were restricted to include only fatally injured persons 16 years of age and over. From table 1, it is noted that this restriction did not reduce the number of drivers used in this study, since not one of the 208 drivers in the total group of 589 fatalities was under 16.

In order to avoid the reporting of postmortem alcohol levels which had been subject to substantial metabolic lowering during the period between accident and death, it was decided to consider only those persons who had died within four hours of their accidents. Table 2 indicates the effect of this restriction on the composition of the group retained for study purposes.

It was initially believed that the study of those drivers who had had alcohol determinations would make possible the ascertainment of whether or not the levels found in heart blood might have been influenced by diffusion of alcohol from the viscera. Since it was reasonably expected that the presence and magnitude of this possible artifact would be a function of the interval between death and the drawing of the specimen at autopsy, the levels were grouped according to the time which had elapsed before the collection of each individual specimen. In doing this it was observed that most of the cases with the longer intervals between death and postmortem examination were those of individuals who, in being killed as the result of evening and early morning accidents, had not had autopsy performed until the next working day. As a result, the group whose examinations had been most delayed was heavily weighted with cases from that period of day in

which a higher percentage of drivers had been drinking and in which relatively higher alcohol levels were present. Because of this selection, it was not possible to demonstrate the presence or absence of an artifact of this type, the possible significance of which is discussed below.

During the eight years studied, 87 single vehicle accidents occurred which involved neither pedestrians nor other vehicles and as the result of which the driver in each case died within four hours of the accident. It will be recalled that it was the description of the blood alcohol levels of this group which constituted the primary objective of this investigation. Fortunately, because of a long-standing interest in the Office of the Medical Examiner[5, 6] in the extent to which alcohol was present among driver fatalities, 83 (95%) of this group had had alcohol level determinations. The resultant data are presented in table 3.

The results given in table 3 show that 41 of the 83 "single vehicle" drivers examined possessed blood alcohol levels of 0.15% or more at the time of death. These constituted 49% of the group. The levels of an additional 17 of this group (20%) fell between 0.05 and 0.15%. In comparison only 22 (27%) were negative. It is noted that the 83 drivers included 7 truck operators, all men, and 6 women operators of passenger automobiles. Of these, one of the former and three of the latter had levels of 0.15% or higher.

Previous Research

The improper use of alcohol as a cause of motor vehicle accidents has been repeatedly reported from many regions of the earth, including Canada, Scandinavia, Germany, France, Italy, the United Kingdom, South Africa, Australia, and the United States. (The *Quarterly Journal of Studies on Alcohol* contains abstracts of technical papers concerned with alcohol, including, in particular, many dealing with motor vehicle accidents.) In view of this, it is remarkable neither that much basic research has been completed nor that much remains to be done.

TABLE 3.—*Alcohol Level by Type of Specimen in Eighty-seven Drivers Involved in Single Vehicle Accidents Who Died Within Four Hours of Accident, Westchester County, New York, 1950-1957*

		Alcohol Level, % by Weight					
Specimen Used	Total	Negative	0.01-0.04	0.05-0.09	0.10-0.14	>0.14	No Examination
None	4	...	...	...	...	...	4
No. examined	83	22	3	11	6	41	...
Blood	66	16	2	6	2	40	...
Brain*	3	1	...	...	2	...	...
Liver*	14	5	1	5	2	1	...
Total	87	22	3	11	6	41	4

*Values shown are actual results of laboratory determinations. Values for brain and liver specimens have not been adjusted for known differences between tissue and blood levels (see text).

In general, research dealing with this problem has largely fallen into two categories: (1) the determination of the extent to which accident liabilities increase in association with blood alcohol level and (2) the determination of the extent to which individuals with such elevated levels are responsible for accidents. Although the present paper is concerned with the second of these research areas, it is appropriate to indicate briefly the findings of the first and to suggest sources of additional information.

Thus, for example, Loomis and West[7] in a recent study with use of "a simulated automobile driving apparatus . . . to evaluate the effect of alcohol as it pertains to several functions involved in driving an automobile," have demonstrated "a direct relationship between the blood alcohol concentration and the extent of impairment of function." Furthermore, these workers found that (1) all of the eight subjects (apparently none of them heavy drinkers) who were tested when their blood alcohol levels were "at or above 0.05% showed some impairment as compared to their control performance," (2) the two subjects who were tested when their blood alcohol concentrations were 0.03% showed performance below control values, and (3) "in the presence of a blood alcohol concentration of 0.15 per cent performance had decreased to approximately two-thirds of the control values."[7, 8]

Other workers, notably Coldwell and others, in "Report on Impaired Driving Tests,"[1] and Bjerner and Goldberg,[9] used objectively scored driving tests given to subjects before and after the use of beverage alcohol. In the most recent of these,[1] 50 adult male subjects, including 5 who "habitually consumed, each day, alcoholic beverages equivalent to at least 6 fl. oz. of distilled spirits" and 5 who "consumed twice this quantity daily," repeatedly drove through a standardized test. The many results of this investigation included (1) the finding of one individual whose performance was impaired at a venous blood alcohol level of 0.04%, (2) the demonstration that one-half of the 50 subjects showed objective impairment of driving ability at a venous blood alcohol concentration of 0.08%, and (3) the finding that all subjects exhibited some evidence of impairment at levels less than 0.15%. The authors pointed out that the men were in a competitive situation which placed a premium on optimum performance and that the test was relatively simple, presenting neither the emergencies nor other hazards present in normal driving.

Two additional studies require mention. In the first of these,[10] by the comparison of the blood alcohol levels of 433 drivers involved in accidents with those of 2,015 driver passers-by, three conclusions were reached: "1. The hazard is significant when the blood alcohol concentration is above 0.010%. 2. In the range of 0.10-0.15% blood alcohol concentration, the hazard of accident is two and one-half times that when the concentration of alcohol in the blood is less than 0.05%. 3. This hazard of accident when blood concentrations are above 0.15% is approximately 10" (i. e., there were 10 times as many drivers with levels of 0.15% and above in the accident-involved group as in the control group of uninvolved drivers). The second study,[11] through the use of samples obtained from 542 of 919 drivers involved in personal injury accidents, compared the blood levels of those rated highly responsible for the accidents in which they were involved with the levels of those rated as either not responsible or only slightly so and demonstrated an increasing statistical excess of accident-responsible drivers which first became significant in the 0.03 to 0.05% range. Additional research[12] conducted in Sweden, with appropriate controls, has shown that

chronic alcoholics and other alcohol abusers were heavily overrepresented in a consecutive series of 2,100 persons convicted of drunken driving.

We do not intend to imply by the title and content of the present paper that we regard the presence of alcohol as the only pertinent characteristic of the individuals described. It might be expected, in fact, that other personal characteristics, themselves associated with individual drinking patterns, would also be related to accident liability. The results of another well-controlled Swedish investigation are of some interest in this connection, however. This study[13] of 71 hospitalized traffic victims showed that, although heavy users of alcohol were highly overrepresented among casualties who had been drinking, they were not overrepresented among those casualties who had not been drinking. These results suggest that the changed liability which the heavy user group exhibited was very closely associated with, if not directly caused by, the use of alcohol.

Medicolegal Interpretations of Blood Alcohol Levels

In the United States, the Uniform Vehicle Code, Model Chemical Test Law, used (July 1, 1957) in 27 of the 48 states,[14] defines (Article IX, Section 11-902) the following presumptions: 1. If there was at that time 0.05% or less by weight of alcohol in the defendant's blood, it shall be presumed that the defendant was not under the influence of intoxicating liquor. 2. If there was at that time in excess of 0.05% but less than 0.15% by weight of alcohol in the defendant's blood, such fact shall not give rise to any presumption that the defendant was or was not under the influence of intoxicating liquor, but such fact may be considered with other competent evidence in determining the guilt or innocence of the defendant. 3. If there was at that time 0.15% or more, by weight, of alcohol in the defendant's blood, it shall be presumed that the defendant was under the influence of intoxicating liquor. (Although there is much individual variation, and although many factors influence the rate of absorption of alcohol and the levels achieved, it is commonly stated that "In order to obtain a blood alcohol level of 0.05% a 150-lb. (68-kg.) person would have to accumulate 1 fluid oz. (30 cc.) of pure alcohol in his body. To do this he would have to drink at least the equivalent of 2 oz. of 100 proof liquor. This same person would have to accumulate 3 oz. of absolute alcohol to reach a blood alcohol level of 0.15%."[18]) 4. The foregoing provisions shall not be construed as limiting the introduction of any other competent evidence bearing upon the question whether or not the defendant was under the influence of intoxicating liquor.

This corresponds to the position of the American Medical Association, which has long endorsed the same limits, "limits (which) were purposely made liberal so that no injustice would be done to the person with unusual tolerance."[15, 16, 17, 18] Nevertheless, proposals for a lowering of the 0.15% limit to 0.05% have been made.[19] It is pertinent, in this respect, that at a 1952 "meeting of Scandinavian criminologists held in Copenhagen . . . the representative of Norway (which has long enforced the 0.05 per cent limit) . . . criticized the Norwegian . . . limit very strongly" on the grounds that it placed undue emphasis on "a chemical determination." The latter position was not supported, however, by "other Norwegian members of the conference."[20]

Significance of Data

With the foregoing findings as background, it was not considered necessary to prove again that the use of alcohol is a causal factor in some motor vehicle accidents. Furthermore, it was not considered necessary to demonstrate once more that there are substantial differences between the distributions of the alcohol levels among accident-involved drivers and those of the driving populations from which they come. It was the purpose, therefore, of the investigation reported here to determine the extent to which individuals with levels already demonstrated to be associated with markedly increased liabilities were present in a group of drivers killed in single vehicle accidents without pedestrian involvement. Fatally injured persons of this type constitute the only group of persons on whom autopsy is performed who may be regarded without additional evidence as having been responsible in most cases for the accidents which cause their deaths. This group offers, as a result, opportunities for study which are not present when pedestrian and multivehicle accidents are considered, since information concerning the principals (i. e., all involved drivers and pedestrians) in, and circumstances of, such events is seldom complete. It also requires neither the personnel nor the expenditures which are required for the collection and analysis of specimens from the principals involved in the more complex varieties of accidents.

An additional reason for choosing one accident type stems from the increasing tendency in this field to compare the alcohol levels found among accident-involved drivers and pedestrians in different communities and jurisdictions. Unfortunately, such comparisons have frequently grouped together dissimilar types of accidents and, in addition, have compared groups of data weighted with those particular combinations of accidents most common in each area considered. If such inevitable comparisons are to be made, it would appear essential that, whenever possible, they be based on the use of careful breakdowns into similar accident categories, since it would be expected that the causes of accidents might vary considerably from one type to another. It is suggested, therefore, that the alcohol levels found in drivers in the "single vehicle group," as used and defined in this paper, may serve as the basis of one form of comparison between jurisdictions which have sufficient fatalities to allow their subdivision to this extent.

This proposal for the use of comparisons based on the levels found in this group is based, as has been noted, on a number of practical limitations in the extent to which inferences may be founded on examinations of motor vehicle fatalities. As such, it too has limitations. The first of these results from the fact that knowledge in this field is so incomplete that it is at present seldom possible to extrapolate quantitatively from fatal to nonfatal accidents or the reverse, a point which is commonly overlooked. In addition, quantitative extrapolations from the single vehicle group to pedestrian and multivehicle accidents must also await the results of additional research dealing with these groups, although it is well known that many of the multivehicle and pedestrian accidents which have occurred

in Westchester and elsewhere have been caused by drivers and pedestrians who were drunk at the time.

It should be noted in this context, however, that related information has long been available concerning the experience of one community, Uniontown, Pa., with another group of drivers presumably responsible for the accidents in which they were involved. Thus, Heise found, in a pioneering investigation reported in 1934 that the alcohol levels of a consecutive series of six apprehended "hit and run" drivers fell between 0.21 and 0.38%, the mean value being 0.30%. By contrast, on the basis of 119 consecutive accidents, he also concluded with respect to pedestrian accidents that "the drivers who struck children or old people were in most cases sober," and that "the largest number of accidents in this group . . . [involved] the drinking pedestrian."[21] This again suggests the need for the careful separation of accidents into discrete categories and the caution which should be used in attempting extrapolations from one group to another.

The limitation of the present series to those dying within four hours of their accidents was based on a compromise between the relatively rapid rate at which alcohol is known to be metabolized[1, 4] and the need for including as many cases as possible in order to facilitate their analysis. In recognizing that the levels in many individual cases have been shown to remain elevated for much longer periods after ingestion than this,[1, 4] it must nonetheless be remembered that many of those killed may well have already been on the descending slopes of their blood alcohol curves at the times of their accidents. For this reason, the four-hour interval is believed to represent a conservative compromise, one that is also supported by the fact that the levels found among those who had died between 4 and 12 hours after their accidents tended to be lower than those found among persons who had died in a shorter time. It is of further interest that 219 of those listed in table 2 had died within two hours and 199 within one hour of their accidents, a point which also has significance from the standpoint of the organization and emphasis of emergency medical care.

It has been mentioned that heart blood had served as the basis for most of the alcohol determinations on which this study was based and that no femoral or other peripheral specimens had been used. This point is emphasized because of the considerable literature dealing with the meaning and relationships of alcohol levels as determined from various portions of the cardiovascular system.[4, 22, 23, 24] Thus, it has long been known that during the stage of active absorption of alcohol from the gastrointestional tract the levels present in the venous return from the limbs may be considerably lower than those found in blood drawn from the heart, a difference which is attributed to the comparatively long time required for the levels in the relatively avascular tissues of the extremities to come into equilibrium with those of the arterial blood.[4] In addition, Gifford and Turkel have demonstrated in a series of 11 cases that whiskey introduced into the stomachs of nonalcoholic cadavers on which autopsy was performed 10½ to 24 hours later consistently produced alcohol levels in heart blood. This suggested that similar false elevations might occur in the heart blood of fatally injured persons whose viscera contained high concentrations of alcohol as the result of the use of alcoholic beverages shortly before death. Since these workers also demonstrated in this series that diffusion into the femoral blood was negligible, it became possible for them to compare individual postmortem heart and femoral alcohol levels in an investigation of the extent to which such an artifact might be present in actual practice. This was done in a series of 51 alcoholic cadavers. The results indicated that the discrepancy sought might prove of considerable medicolegal importance in occasional cases. It was also demonstrated, however, that the average excess of the heart blood alcohol level over that found in the femoral vein was slightly less than 0.01%.[23] In view of the latter finding, it is considered improbable that such a diffusion artifact had to any appreciable extent influenced the alcohol levels given in the present report.

The results of the investigation reported here show that at the time of death 49% of the drivers killed in single vehicle, nonpedestrian accidents possessed blood alcohol levels of 0.15% or more by weight. These levels are widely accepted on the basis of a considerable body of scientific knowledge as presumptive evidence of drunken driving. An additional 20% of the drivers in this group possessed levels between 0.05 and 0.15%. As discussed above, it has been shown that many persons with levels in this range not only exhibit measurable deteriorations in driving performance but also are overrepresented in accident groups.

In view of these findings from Westchester County, it is appropriate to question the extent to which similarly elevated levels might be found elsewhere in fatally injured persons of this type. Fortunately, one set of data already existed which was indicative of the somewhat comparable experience of another section of the United States. Thus, the Delaware State Police have studied all fatal accidents occurring each year at locations outside of the city of Wilmington, with particular reference to the alcohol levels of most principals. As a result it has been possible, on the basis of data made available to us through the courtesy of the Delaware authorities,[25] to identify a group of fatally injured drivers similar to the single vehicle drivers studied in this report. This group consists of the 15 fatally injured drivers during 1957 whose passenger automobile accidents involved neither pedestrians nor other vehicles and who were listed as having died either at the scene of the accident or prior to arrival at the hospitals to which they were taken. Ten (67%) of this group were found to have blood alcohol levels of 0.15% or more, and two had levels between 0.10 and 0.15%. These data suggest that the high alcohol levels observed among drivers killed in single vehicle accidents in Westchester County may exist in other sections of the United States.

Summary

In conclusion, it is recalled that Heise stated in 1934 "that the problem of controlling the drinking driver and pedestrian is far from being solved may be due, in part, to the fact that no accurate statistics are available regarding the relationship of alcohol to automobile accidents. . . ."[21] On the basis of the findings presented in this report and previous work in this field, it appears highly probable that the use of alcohol was a causal factor in the deaths of one-half or more of the drivers killed in the single vehicle accidents which occurred in Westchester County over an eight-year period.

The postmortem blood alcohol levels were studied in a group of 83 drivers whose fatal accidents involved neither pedestrians nor other vehicles and whose deaths followed within four hours. Forty-nine per cent of the 83 were found to have had blood alcohol levels of 0.15% or more at death, while those of an additional 20% fell between 0.05 and 0.15%. From this and previous studies it is concluded that it appears highly probable that the use of alcohol was a causal factor in the deaths of one-half or more of the drivers killed in the single vehicle accidents which occurred in a suburban county over an eight-year period.

The authors wish to express their appreciation to Mr. Andrew Frey and Mr. Morton Berk for performing the many chemical analyses on which this report is based. They also wish to thank Mrs. Helen C. Chase and the staffs of the Driver Research Center and the Office of the Medical Examiner for their most generous assistance.

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OPERATIONS ANALYSIS OF TRAFFIC SAFETY

PART III

Methods of Evaluating Traffic Situations

by Fletcher N. Platt

This is the third part of a report that presents a framework for analysis of the whole traffic safety problem. Parts I and II of this paper developed a theoretical model of traffic situations and, with available information, proposed certain formulas and equations.[1] Part III presents a brief discussion of operations analysis and the scientific method. Following the format of this method, fundamental goals, measures of effectiveness, research needs, methods and techniques for analyzing the problem will be discussed. Several examples of the economic evaluation of changes in the traffic system are given. Appendices cover methods of dimensional and exposure analysis.

OPERATIONS ANALYSIS AND SCIENTIFIC METHOD

This paper adapts certain techniques from Operations Analysis[2] for the purpose of evaluating the traffic safety problem. Operations Analysis is a relatively new technique. It is now being applied in many areas, such as business management and logistics.

What is Operations Analysis? It is a method involving a particular view of operations, and even more importantly, a particular kind of analysis.

Operations are considered as an entity. The subject matter is not just the equipment used, nor the morale of the participants, nor the physical properties of the output, it is the combination of these, as a total process. Operations so conceived are subject to analysis by the scientific method associated with the research work of the physicist and the chemist.

Scientific method presumes the rationality of nature; that every phenomena has a cause. If this is so, then the scientists' job is to determine the mechanism or system underlying the facts. The scientist knows that his analogy to nature is never perfect. However, it must be "accurate enough" to suit the particular purpose at hand. Until it is sufficiently accurate, he must repeat the processes of observation, induction, theory construction and experiment.

There are four fundamental parts of Operations Analysis:

1. The Model

The model is the simplified representation of an operation, containing only those aspects which are of primary importance to the problem under study.

2. The Measure of Effectiveness

The measure of effectiveness is the yardstick for checking how well an operation is attaining its goal. A consistent statement of the fundamental goals of the operation is essential to the mathematical logic of the model.

3. Necessity for Decision

An essential element in operations analysis is the existence of alternate courses of action; the necessity for decisions.

4. Experimentation

Operations analysis applies experimental science to the study of operations. The theory, or model, is generally built up from observed data and experience. Theory describing operations must always be checked experimentally.

Two types of experiments are required:

1. for basic information
2. for testing the validity of theory and constants.

TABLE I

FUNDAMENTAL GOALS AND VIEWPOINTS

Fundamental Goals	Viewpoints			
	Individuals	Society	Commerce	Insurance
(To minimize one or more of the following)				
Time of Travel	✓	x	✓	x
Total Cost of Travel	✓	x	✓	x
Total Cost of Accidents	x	x	x	✓
Number of Fatalities	✓	✓	x	x
Number of Injuries	✓	✓	x	x
Operating Limitations	✓	x	✓	x

Ranking
✓—Primary Importance
x—Secondary Importance

Additional Factors for Consideration
Passenger Comfort
Prestige of Ownership
Standards of Courtesy
Psychological Effect on Driver

GOALS AND VIEWPOINTS

The traffic operations model was developed in Parts I and II. Therefore, the next procedure is to establish measures of effectiveness. However, it is first necessary to decide what viewpoints should be taken and what priorities should be given to various fundamental goals of the sys-

tem. Table I lists the major goals that should be considered. The evaluation of viewpoints suggested by the author are only for illustration.

It might be desirable to rank these goals in numerical order or value for complex operations analysis.

RELATIVE IMPORTANCE—IN ACCIDENTS

In traffic safety, it is generally assumed that reduction of fatalities is most important. However, injuries account for far more human suffering, as well as greater economic loss. According to a recent study by the Bureau of Public Roads[3] the direct cost of fatal accidents are 3 per cent of the total, personal injury accidents 57 per cent, and the remaining 40 per cent from property damage.

In terms of numbers, compare 38,500 killed in 1957 from traffic accidents to 1,400,000 injured (with disabilities beyond the day of the accident) according to the National Safety Council.[4] Over 100,000 persons are permanently disabled each year. Thus, for the purpose of this analysis, it seems reasonable to give equal importance to the reduction of injuries and fatalities. Reduction of property damage resulting from accidents has economic significance, but in the author's opinion must be rated secondary to human casualties.

Losses due to traffic accidents can be stated in numerous ways. Table II lists some of these.

TABLE II

LOSSES DUE TO TRAFFIC ACCIDENTS

1. Life
2. Injuries—Pain and Discomfort
3. Direct Costs
   - Property Damage
   - Hospital and Medical Expense
   - Legal and Court Fees
4. Indirect Costs
   - Lost Earnings—Current and Future
   - Insurance—Overhead and Profit
   - Lost Earnings of all Traffic Delayed
   - Police Investigation
   - Accident Records
   - Accident Research
5. Time
   - Individuals Involved
   - All Traffic Delayed
   - Police
   - Medical and Related Personnel
   - Dependents of Individuals Involved

ECONOMIC EVALUATION—COST OF ACCIDENTS

Since the cost of accidents has received so much attention, an economic evaluation of this goal will be made to demonstrate one use of this analysis.[5] A suggested method for using mathematical programming to include several goals simultaneously will be suggested later.

The procedure is first to establish the average cost of collisions, injuries, and fatalities, individually. The study by the Bureau of Public Roads determined the direct cost of accidents (in one state), and indirect costs have been estimated by several authors. Table III is in the order of magnitude suggested in other reports. These figures will be used as the basis for several examples illustrating economic evaluation of traffic situations.

Establishing the cost of a human life may be considered presumptuous but is necessary in order to carry out the analysis. Although the measurable costs are estimated in Table III, a weighting factor could be applied to emphasize the importance of life in the analysis. For instance, fatalities might be given a weighting factor of ten, thus raising the cost to $250,000.

TABLE III

ESTIMATED AVERAGE COST OF TRAFFIC ACCIDENTS

	Property Damage Collisions	*Injuries*	*Fatalities*
Direct Cost[2]	$ 200	$ 860*	$ 5,200*
Indirect Cost[5] (Estimated)**	100	1,140	19,800
Total Costs	$ 300	$ 2,000	$ 25,000

*Includes property damage, hospitalization, doctors, dentist and nurses service; damages awarded, attorney's fees, court fees, and other small miscellaneous items.

**Includes loss of future earnings, overhead cost of accident insurance, high school driver training, safety engineering, traffic courts, traffic police, and all traffic accident prevention activities.

In order to study a change in any part of the traffic system it is necessary to relate the odds of traffic situations to one another. Particularly, the ratio of the three situations that are directly related to cost.

Table IV shows the ratios of situations in relation to collisions, injuries and fatalities. Underlined ratios are used in the calculations of Table V to determine relative values. The odds of the traffic situations are from Part I, Table I. (If measured odds are available for the particular highway location under study, these should be substituted accordingly.)

On the basis of Table III and IV, the relative value of traffic situations has been computed and listed on Table V. These values of traffic situations are used in the following examples of economic evaluation of the traffic system.

These examples have been selected to illustrate the use of the method in each of the major areas of traffic safety activity.

TABLE IV

RATIOS OF TRAFFIC SITUATIONS TO COLLISIONS, INJURIES AND FATALITIES

Situations	*Odds Per Mile*	*Ratio*		
		Collisions	*Injuries*	*Fatalities*
Events	200	12,200,000	86,000,000	3,200,000,000
Decisions	20	1,220,000	8,600,000	320,000,000
Errors	1 / 2	30,500	215,000	8,000,000
Near Collisions	1 / 500	122	860	32,000
Collisions	1 / 61,000	1	7	262
Injuries	1 / 430,000		1	37
Fatalities	1 / 16,000,000			1

TABLE V

RELATIVE VALUE OF TRAFFIC SITUATIONS

Situations	Calculations*	Total Cost Per Situation	Situations Per Dollar
Fatality		$25,000	...
Injury	$2{,}000+\frac{25{,}000}{37}$	= $ 2,675	...
Collision	$300+\frac{2{,}000}{7}+\frac{25{,}000}{262}$	= $ 680	...
Near Collision	$\frac{680}{122}$	= $ 5.60	...
Error	$\frac{680}{30{,}500}$	= $ .0224	45
Decision	$\frac{680}{1{,}220{,}000}$	= $ .000558	1,800
Event	$\frac{680}{12{,}200{,}000}$	= $ .0000558	18,000

*Cost from Table III, Ratios from Table IV.

ECONOMIC EVALUATION—HIGHWAY DESIGN

Example #1

A certain section of highway has 50 hazards (events) along the shoulder, including trees and unguarded abutments.

Traffic averages 5,000 vehicles/day.
5,000 × 50 = 250,000 vehicles events/day.
Loss (from Table V) 18,000 events/dollar.

$$\frac{250{,}000}{18{,}000} \times 365 = \$5{,}080 \text{ per year loss.}$$

Assume a total cost to remove the hazards is $21,000 then the cost of removal will be amortized in

$$\frac{21{,}000}{5{,}080} = 4 \text{ years, 2 months.}$$

Example #2

A section of state road with an average traffic load of 2000 vehicles a day has unlimited access from 20 side roads and driveways. A survey is made and it is determined that 250 vehicles a day enter by these roads. Assume that entering is a hazardous event, and may influence an average of four vehicles on the main thoroughfare. Also, anyone of the 2000 vehicles may exit by one of the 20 side roads, and will influence an average of two other vehicles.

The number of hazardous events is
(250 × 4) + 2 (2,000 × 20) = 4,000 + 80,000
84,000 vehicle events per day.
Loss (from Table V) = 18,000 events per dollar.

$$\frac{84{,}000 \times 365}{18{,}000} = \$1{,}700 \text{ per year.}$$

It is estimated that a service road would cost $95,000 for this section of road, which was obviously not justified. However, it was decided that speed zoning to 45 m.p.h. would reduce the hazard appreciably at a cost commensurate with the potential loss.

ECONOMIC EVALUATION—TRAFFIC ENGINEERING

Example #1

A community had a 25 m.p.h. speed zone on two miles of a street heading out of town. Accidents have averaged 40 vehicle collisions plus four pedestrian accidents per year.

On a trial basis, the speed limit has been increased to 40 m.p.h. There have been 30 vehicle collisions over the first six months (or an increase of 20 per year). Pedestrian accidents have not changed. A traffic survey shows that average traffic speed has been increased from 20 m.p.h. to 30 m.p.h., with the same average volume of 3000 vehicles per day.

Loss due to increased collisions = 20 × 680 = $13,600 per year.

Savings—Assuming time saved @ $1.00 per hour and two occupants per vehicle = $2.00 per vehicle.
Time saved = 2 minutes per vehicle.

$$\$2.00 \times \frac{2}{60} \times 3{,}000 = \$200 \text{ per day.}$$

200 × 365 = $73,000 saved in time as a result of the new speed limit.
Net saving = $73,000 — $13,600 = $59,400 per year.

Although accidents have increased somewhat, the economic saving is worth further investigation.

Example #2

Assume, in the example above, that a detailed study is made of the accidents that have occurred in the last six months. It shows that property damage accidents have increased by five per year, and injury accidents have increased by 15 per year. There have been no fatalities.

The loss can now be calculated as follows:

(5 × 300) + (15 × 2,000) = 15,000 + 30,000
= $31,500.
Net savings = $73,300 — $31,500 = $41,500 per year.

ECONOMIC EVALUATION—DRIVER EDUCATION

Example #1

Surveys indicate that high school driver education reduces violations and accidents by 50 per cent in the first several years of driving. It has been estimated from a study by the A.A.A.[6] student drivers make 1.3 moving errors per mile, and it is assumed that new drivers average 5000 miles per year.

If driver errors are reduced 50 per cent, then

$$\frac{1.3}{2} \times 5{,}000 = 3{,}250 \text{ errors reduced per driver year.}$$

Loss (from Table V) = 45 errors per dollar.

$$\text{Savings equals } \frac{3{,}250}{45} = \$72 \text{ per year.}$$

The average cost of driver education is $34 per student. The investment will pay off in less than six months.

Example #2

Assume that periodic driver re-examination and public education through radio, television and the press has shown to reduce driver errors by an average of 10 per cent. The average driver makes one error every two miles and drives about 8000 miles per year.

$\frac{8{,}000}{2} = 4{,}000$ errors per year.

Reduction of errors $0.10 \times 4{,}000 = 400$ per year.

Loss (from Table V) = 45 errors per dollars.

It would be economically sound to spend up to $\frac{400}{45} =$ $8.90 /driver/year if a 10 per cent reduction in errors could be realized.

ECONOMIC EVALUATION—SEAT BELTS

Does the savings from the use of seat belts justify the cost of installation?

Cornell Crash Injury Research[7] predicts an estimated reduction of injury by properly designed and installed belts to be:

Any degree—60 per cent.

Critical and fatal—70 per cent.

National Safety Council Facts, 1957 Data[4]—

Occupant injuries—1,130,000 (Estimated).

Occupant fatalities—30,170 (Total traffic deaths less pedestrian and cyclist deaths).

Estimated savings if all occupants wore belts—

Injuries—$1{,}130{,}000 \times .60 \times \$2{,}000 = \$1{,}355{,}000{,}000$

Fatalities—$30{,}170 \times .70 \times \$25{,}000 = \quad 528{,}000{,}000$

Per Year $1,883,000,000

Total cost of installing belts—

5 seats @ $8 = $40 per car $\times$ 52 million = $2,080,000,000

2 seats @ $8 = $16 per truck $\times$ 10 million = 160,000,000

$2,240,000,000

Belts would be amortized in $\frac{2{,}240}{1{,}883} = 1$ Year, 2 Months.

(Expected belt life: 3 to 5 years minimum.)

ECONOMIC EVALUATION—VEHICLE INSPECTION

There is considerable controversy regarding the importance of vehicle inspection and the extent to which faulty equipment relates to accidents. The most conservative estimates indicate that 5 per cent of the accidents result from equipment failure. The 1958 Vehicle Safety Check program[8] conducted in more than 2000 communities on three million vehicles show that nearly 20 per cent of the vehicles had one or more safety items below standard (including steering, headlights, tail lights, windshield wipers, glass, mirror, horn, brakes and tires).

To illustrate, assume that a vehicle inspection system in a state of three million vehicles would reduce the number of near collisions by 5 per cent.

$3{,}000{,}000 \times 10{,}000 = 30$ billion vehilces miles/year.

Assuming 500 miles/near collision, then

$\frac{30 \text{ billion}}{500} = 60$ million near collisions.

Reduction, $60{,}000{,}000 \times .05 = 3{,}000{,}000$ near collisions.

Loss (from Table V) = $5.60/near collision.

Saving = 3 million $\times$ $5.60 = $16,800,000 per year or $5.60/vehicle/year.

ECONOMIC EVALUATION—ENFORCEMENT

On a 50 mile section of state highway, a survey has shown that during a three month trial, accidents have been reduced from 20 to 10 (using a three year average during the same period) by adding one additional patrol car during the peak periods of traffic (one shift).

The cost of the added enforcement officer, equipment and overhead =

$\$16{,}000$ per year.

$\frac{16{,}000}{4} = \$4{,}000$ for three months.

Estimated savings (based on formula)

10 collisions @ $680 = $6,800

Average saving = $(6{,}800 - 4{,}000) \times 4 = \$9{,}600$ per year.

ECONOMIC EVALUATION—MEDICAL TECHNIQUES

Assume that a new shock treatment for trauma is developed by the medical profession that will give an injured person a 10 per cent better chance of survival. It is estimated that at least 10 per cent of the casualties could benefit from the new treatment.

Total savings:

$38{,}500 \times .10 \times .10 \times (\$25{,}000 - \$2{,}000) =$

$385\ (23{,}000) = \$8{,}860{,}000$ savings per year.

A research project costing several million dollars would be a good investment if these savings could be realized.

RESEARCH REQUIREMENTS

The scientific method requires two types of research, to obtain basic information and experiments to verify theory. Both types are needed to determine the value of this theoretical analysis on traffic safety.

The following paragraphs outline the kinds of research necessary to obtain the basic parameters and constants for an accurate analysis of traffic safety situations. Table VI establishes a framework for the needed research.

1. The number of events shall be counted, by actual measurement, in many traffic conditions. Both continuous and discrete events should be noted, as well as those related and unrelated to the driving task. Hazardous events should be recorded separately.
2. Drivers should be studied to determine the number of observations, decisions and actions taken under various types of traffic and highway conditions. Situations related and unrelated to the driving task should be evaluated.[9]
3. Correct and incorrect actions must be defined within

TABLE VI

RESEARCH REQUIREMENTS

Situations	Definitions	Measurements				Analysis			
		Vehicle	Driver	Highway	Environment	Simple Interrelationship	Operations	Corrective Measures	Cost
Events									
Observations									
Decisions									
Actions									
Errors									
Near Collisions									
Collisions									
Injuries									
Fatalities									

reasonable limits and the latter compared to individual driver's violation and accident records. Actions should also be considered with respect to age and training of the driver as well as psychological variables.[10]

4. Techniques need to be developed for studying near-collisions and relating them to incorrect actions on one hand and collisions on the other. Investigation of the near-collision may be a key to devising new ways of reducing collisions.
5. Crash research conducted by the automotive manufacturer and several universities must be continued on a coordinated basis.
6. Studies of automotive crash injuries have been conducted by Cornell University research group for five years. This research must continue to seek basic information regarding the cause of crash injuries and the parameters that can reduce injuries and fatalities. More valuable information is currently available in this area than any other.
7. Definitions, methods of measurement, exposure criteria and progress reporting systems shall be established in each area mentioned above.
8. Distribution patterns of each parameter shall be obtained and verified under numerous conditions for expansion of the method in statistical techniques.
9. Modify parameters one at a time to determine effect on the whole system, theoretically and experimentally.
10. Modify related groups of parameters to study the effect on the total system.
11. Mathematical programming and other analytical methods shall be used to evaluate the complete traffic safety problem and the theory that has been developed.

SOPHISTICATED METHODS

The author has not attempted to go into the more sophisticated methods of analysis that are available to the mathematician and scientist. The following paragraphs will suggest some methods that will probably be useful in developing this procedure in greater detail.

a. Statistics[11,12,13]

The traffic situation approach is obviously based on the probability theory, a fundamental part of statistics. A broader application of statistics in all phases of the analysis is recommended. The formulas in Part II are based on average situations and could be replaced with limits based on measured distribution.

b. Mathematical Programming[14]

Mathematical programming can be applied, after fundamental parameters are measured from experiment, to establish the inter-relationships and relative importance of the major components. Specific studies of special problems will be aided by the use of this method. This is the basis for operations analysis of traffic safety.

c. Theory of Games[17]

"This theory deals with games in which the players have the opportunity to make choices and use rational strategies such as chess, where no chance is involved, or bridge and poker, where a mixture of chance and strategy occurs." In driving both chance and strategy play a part and so it seems possible to set up mathematical models of certain traffic situations and predict results by this theory.

d. Servo Theory[18]

The driver is part of the loop in control mechanism of the vehicle. The controls of vehicles are designed with this in mind. Perhaps a closer inspection of theoretical requirements of a servo will give a new insight into driver training techniques and clues to new devices to aid the driver.

e. Motivation Research[16]

Methods used in motivation research could possibly be applied to learn more about driver motivation. It would seem logical to use this in the study of risk taking and the acceptability of certain laws, enforcement techniques and traffic controls. An example of its use is illustrated by

TABLE VII

THE EPIDEMIOLOGICAL APPROACH

	Medicine	Traffic Safety	Industrial Safety	Sports
HOST	Immunization to prevent disease	Driver training	Safety education program	Coaching
HOST & AGENT	Medication to lessen severity of disease	Eliminate crash injury hazards on vehicle—seat belts	Safety goggles, gloves and helmets	Football helmets, baseball and boxing gloves
AGENT & ENVIRONMENT	Kill mosquitoes and purify water	Improve brakes, visibility on vehicles	Safety guards on machines, non-skid floor	Boxing ring ropes
ENVIRONMENT	Eliminate slum areas	Remove roadside hazards (abutments and trees)	Keep plant clean and well lighted	Clean facilities and equipment

a recent study[21] that shows that "nine out of ten drivers in this investigation (and 100 per cent of those with a record of violations) rated themselves above average in driving skill; and they say they're better than average at obeying traffic laws, too."

f. Cybernetics[18]

Cybernetics is the study of control and communication systems of man and machine. A review of cybernetics in relation to the design and operation of motor vehicles offers a whole new viewpoint. Particularly, the sequence of driver observations, decisions and actions could be evaluated by scientists familiar with cybernetics with the possibility of developing a new approach to this part of the problem.

g. Epidemiological Approach[19]

The medical profession follows the scientific method in their techniques used to study epidemics of disease. Traffic accidents can be considered in the same way. Epidemiology determines by theory and experiment the relationships between the host, the agent and the environment. In the case of traffic, the driver, passenger or pedestrian is the host, the car is the agent. Environment includes the road, the traffic and all other external conditions.

Doctors, after studying a contagious disease, take action to combat its transmission, and reduce its effect if contracted. There are many ways this is done. Table VII is a chart giving examples of the epidemiological approach in medicine, traffic safety, industrial safety and sports.

SUMMARY AND CONCLUSIONS

This paper has developed a new method which permits logical procedure for the evaluation of the traffic safety problem. Part I presented "A Classification of Traffic Situations" to define in detail the fundamental parameters relating to the subject. The second part developed emperical formulas and equations on the basis of classifications. This part establishes a basis for selecting fundamental goals, measures of effectiveness, and outlines research needs and suggests methods and techniques that might be useful.

It must be apparent to the reader that further analysis will be of little value until sufficient research is completed to validate the theory and establish fundamental constants. Once this has been accomplished, it will then be possible to explore the use of sophisticated techniques discussed in the last part of this section. Until that time, the value of this report will probably be limited to use of the classification system and the comparatively simple method described for evaluating the merits of individual changes in traffic situations.

The author wishes to acknowledge, with thanks, the thoughtful comments of those who reviewed Parts I and II. Suggestions from the following were particularly valuable:

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APPENDIX A

DIMENSIONAL FACTORS

In Part I, the "Odds of Traffic Situations" were described in the dimension "units per mile". Refinement requires consideration of all reasonable dimensions for different situations and use of the most appropriate ones for each particular study.

Table VIII, "Dimensions of Traffic Situations", presents the dimensions that might be of value.

Units

All situations can be measured in units. However, to make comparisons under different conditions, it is necessary to establish logical dimensions for each situation.

Units Per Hour (Day, Month, Year)

If special consideration is being made in a study regard-

TABLE VIII

DIMENSIONS OF TRAFFIC SITUATIONS

Situations	Units	Units Per: Hour (Day, Year)	Highway Mile	Vehicle Mile	Driver Mile (Driver Hour)	Occupant Mile (Occupant Hour)	Pedestrian Hour (Cyclist Hour)	(Highway Vehicle, driver occupant) Mile Per (Hour Day, Year)
Events	x	x	x	x	x		x	
Observations	x	x			x		x	
Decisions	x	x			x		x	
Errors	x	x			x		x	
Actions	x	x			x		x	
Near Collisions	x	x	x	x	x	x	x	x
Collisions	x	x	x	x	x	x	x	x
Injuries	x	x				x	x	x
Fatalities	x	x				x	x	x

ing time of day, seasonal environment, year to year comparison, then the dimension "units per time" may be important without regard to other dimensions.

Units Per Highway Mile

This dimension should be used when studying highway characteristics.

Units Per Vehicle Mile

This dimension can be used when studying vehicle characteristics in relation to the number of events, near collisions or collisions per mile. (Injuries and fatalities are usually measured in this dimension. However, because other factors are involved in the probability of injury or death resulting from collision, other dimensions will be recommended.)

Units Per Driver Mile

All traffic situations from events to fatalities can be considered on the basis of units per driver mile. When studying driver behavior and the differences in driver characteristics, this dimension is useful.

Units Per Driver Hour

When considering certain physiological factors in driver behavior such as the effect of fatigue, drugs and alcohol, time is often more important than distance. Under some circumstances, then, the dimension "situations per driver hour" should be used.

Units Per Occupant Mile

The study of situations pertaining to occupants (i.e., driver and passengers) include near collisions, collisions, injuries and fatalities. This dimension is seldom used, although it is far more rational than "vehicle miles" when considering injuries and deaths.

Units Per Occupant Hour

Special case studies might find this dimension of value. For instance, the study of passenger fatigue compared to driver fatigue, and the effect of mutual tensions on long trips may be more a matter of time than distance travelled.

Units Per Pedestrian (Cyclist) Hour

Usually pedestrians and cyclist situations are considered in terms of vehicle miles. It seems more logical to evaluate pedestrian and cyclist situations in respect to their own exposure to vehicles rather than vehicle exposure to them. It is reasonable to evaluate pedestrian and cyclist situations in the dimension of time rather than distance, and completely separate traffic casualties into two basic groups; occupants and others (pedestrians and cyclists).

Units Per Highway (Vehicle, Driver, Occupant) Mile Per Hour (Day, Year)

Some studies require a comparison of distance rates over a given time period. For example, compare fatalities per 100 million occupant miles in 1956 to 1958. There are many other obvious combinations in this complex dimensional study.

APPENDIX B

EXPOSURE TO HAZARDOUS SITUATIONS

The dimensional analysis is not necessarily related to hazardous situations. However, the study of the undesirable aspects of traffic situations, collisions and casualties creates the need for measuring exposure to hazards. If exposure to collisions, damage and injury is clearly defined, and a means of measuring exposure is agreed upon, then any reduction in exposure will have a direct relation to reduction of collisions, damage and injury.

In previous sections of this paper, events were not divided into hazardous and non-hazardous types. However, a study of exposure will require such a classification.

For example, other vehicles, abutments, trees and utility poles along the road are examples of hazardous events, while the center line in the road or the gas gauge in the car would be non-hazardous events. A warning sign or signal might fit into either classification depending on its mass and location. A sign mounted on a heavy structure along the shoulder is obviously a hazardous event.

The usual measures of exposure, vehicle miles, vehicle registrations, and populations are not reliable measures of exposure to hazardous situations. In order to analyze a traffic problem, to measure progress of a system change or to compare records of two or more locations, a more realistic method of establishing exposures is required. The factors shown on Table VIII are considered applicable.

EXPOSURE TO POSSIBLE COLLISIONS

Exposure to different types of collisions will vary. Vehicle to vehicle, single vehicle, pedestrian and cyclist col-

TABLE IX

EXPOSURE TO POSSIBLE COLLISIONS

Type of Hazard	Ref.	Unit Exposure (1)	Total Vehicle Exposure (2)	Total Persons Exposed (3)
Vehicle to Vehicle				
Head-On		R_o	R_oR_a	$R_TR_oR_a$
Front to Rear	Equation VI Part II	$(E_d)_{sp}+(E_d)_{sq}$	$R_a[(E_d)_{sp}+(E_d)_{sq}]$	$R_T(R_a[(E_d)_{sp}+(E_d)_{sq}]+R_o[(E_d)_{op}+(E_d)_{oq}])$
Intersecting	Equation X Part II	$(E_d)_i$	$(R_a+R_o)(E_d)_i$	$R_T(R_a+R_o)(E_d)_i$
Single Vehicle				
Fixed Object	Table III Part I	R_s	$R_s(R_a+R_o)$	$R_TR_s(R_a+R_o)$
Roll-Over		$(V_x)^n$	$(R_a+R_o)(V_x)^n$	$R_T(R_a+R_o)(V_x)^n$
Pedestrian				
Crossing		$(R_aV_a+R_oV_o)t_s$		$(R_s)_i(R_aV_a+R_oV_o)t_s$
Parallel		$(R_aV_a)(t_s)_a$; $(R_oV_o)(t_s)_o$		$[(R_s)_a(R_aV_a)(t_s)_a+(R_s)_o(R_oV_o)(t_s)_o]$
Cyclists				
Crossing		$(R_aV_a+R_oV_o)t_s$		$(R_s)_i(R_aV_a+R_oV_o)t_s$
Parallel		$(R_aV_a)(t_s)_a$; $(R_oV_o)(t_s)_o$		$[(R_s)_a(R_aV_a)(t_s)_a+(R_s)_o(R_oV_o)(t_s)_o]$

(Notation from Part II, t = time.)

lisions are major variables as listed in Table IX. Exposure for specific types of collisions within these groups are listed as sub-headings in the first column.

Exposure can be considered from several viewpoints on the type study being made.[20] The first consideration is to determine the hazardous events that occur to a single vehicle, pedestrian or cyclist on a roadway (Column 1). If the equation for this exposure is multiplied by the proper vehicle density, the total vehicle exposure is obtained (Column 2).

Obviously, the total persons exposed to these hazardous events are a function of vehicle exposure times the average

Injury *Potential of Seating Areas**

	% Injured : To Any Degree	To Moderate-Fatal Degree	To Dangerous-Fatal Degree	To Fatal Degree
Driver Area*	78%	31.2%	10.9%	5.3%
Front Seat Passenger Area	81%	33.1%	9.7%	5%
Rear Seat Area	60%	17.5%	4.6%	2.6%

* *Based on Rural-injury producing accidents.*

* *Drivers unaccompanied by passengers must be injured in order to become part of the A.C.I.R. sample. Thus the data are somewhat biased with respect to frequency of driver injury.* -- 1956

number of occupants per vehicle. The number of occupants per vehicle will vary with time of day, day of week, and time of year. It is important that occupant number be estimated when evaluating the effect of time relationships.

(It should be noted that the number of potential collisions in the vehicle to vehicle types will be about one-half of the total vehicle exposure.)

Since the pedestrian and cyclist will be injured when struck by a vehicle, not vehicle occupants, the exposure factor should be on the basis of pedestrian or cyclist exposure to vehicles, not vehicle exposure to pedestrians.

Column 3 presents equations for pedestrian and cyclist exposure to vehicles in terms of units of exposure rather than miles travelled. (Obviously, the total exposure to hazards will be the summation of the individual hazard formulas in any column.)

EXPOSURE TO DAMAGE AND INJURY

Not only must gross exposure to collisions be considered, but also exposure to certain specific hazards that result in the extent of damage and degree of injury received.

Table XIII of Part I lists the major factors relating to types of collisions. Crash tests by Ford Motor Company, University of California—UCLA, USAF Aero Medical Laboratory and other automobile manufacturers have developed criteria establishing basic relationship between these factors. Cornell University Crash Injury Research program has substantiated the results of laboratory tests by statistical and clinical studies of actual highway collisions in twenty-two states. On the basis of these tests and analyses, exposure constants can be estimated for specific situations.

Table X is an example of measurement of exposure to injury as a function of seating position (Cornell Crash Injury Research).

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THE EFFECTS OF DRIVER IMPROVEMENT ACTIONS ON DRIVING BEHAVIOR

by B. J. Campbell

Note: This study is part of a research project carried out by the Institute of Government for the American Association of Motor Vehicle Administrators. The project was made possible by a grant from the Esso Safety Foundation. The complete report of the project is entitled Driver Improvement: The Point System.

Introduction

The practice of withdrawing driver licenses upon conviction for certain violations of the motor vehicle law is almost universal in North America. The law in most jurisdictions requires revocation of the driving privilege upon conviction for any of several specific offenses, and permits suspension for others. Moreover, in most jurisdictions the license may be taken for an accumulation of offenses even though none warranted action by itself. In recent years increasing amounts of attention have been given to the latter group of drivers whose total record is serious though no single offense is particularly flagrant. These driver improvement programs have in common the fundamental assumption that drivers who violate motor vehicle laws are dangerous and must be dealt with.

Driver improvement programs can justify their existence only to the extent that they accomplish their fundamental purpose—that of bringing about desirable changes in the "behind-the-wheel" behavior of drivers with whom they deal. McFarland [3] has mentioned the lack of studies concerning the socio-legal control of drivers and has stated that there is need for carefully controlled research in this area. The lack of clear-cut evidence showing that driver improvement programs produce desirable changes in drivers indicates a necessity for investigating the fundamental effectiveness of such programs before proceeding too far with elaborate refinements which carry the implicit *assumption* that they are effective. For this reason, one of the major undertakings of this study was an investigation of changes in driver behavior subsequent to departmental action.

The organization of this study is more easily presented if driver improvement action is thought of as involving (1) a process of selecting drivers in need of attention, and (2) a policy of taking one of several actions toward each such driver. It is basic that driver improvement programs need to contact the drivers most likely to cause or be involved in motor vehicle accidents and through appropriate action to reduce this tendency. At first glance it would seem that departments would therefore select for action those drivers who have the most accidents. The actual and universal fact is, however, that action is initiated toward most drivers not because they have been involved in accidents, but because they have been convicted for violations of the motor vehicle law (most of which had nothing to do with an accident). This policy is pursued on the assumption that drivers who violate the law are more likely to cause or be involved in accidents than drivers who do not violate the law. Kelly [2] stated this fundamental assumption very well when he referred to a violation as "a symptom of an accident to come." Of course, many jurisdictions have programs under which accident repeaters are designated for some kind of attention, but, by far, the majority of candidates for driver improvement are selected on the basis of violation records.

After the process of selecting the driver comes the problem of deciding the type of action to be taken toward those selected for driver improvement. One of the most common actions is that of suspending the driving privilege, which presumably reduces the immediate hazard by removing the dangerous driver from the road and reduces the future hazard by making him drive more carefully in order to avoid losing his license again. Probation is another common device used in driver improvement which, presumably, produces desired changes by making him understand that a breach of probation will result in suspension. Advisory letters are used even more frequently than the preceding methods and are thought to have persuasive value in improving drivers.

The basic task of this study is to evaluate the subsequent record of drivers selected on the basis of violations and dealt with in certain ways including suspension, probation, etc. The subsequent record might be expected to show a decrease in accidents and violations, and the decrease should be of sufficient magnitude to be attributable to departmental action. Moreover, the influence of this action might be shown through changes in the type of violation committed subsequently and through the time lapse between departmental action and the next offense.

Design of the Study

In New Jersey, where the data for this study were gathered, a point system is in operation. Each motor vehicle violation carries a certain number of demerit points, and when a driver accumulates a certain number of points, some driver improvement action is taken toward him. Drivers receiving such action constitute the experimental group, and changes in their driving records after action are compared with changes in the record of control drivers whose records warranted action, but who received none.

The necessity for a control group would seem to rule out the possibility of an adequate study, because the usual policy in driver improvement is to take action toward *all* drivers at a given level. Thus, ideally, there would *not* be any drivers who warranted but did not receive action. It is found, however, that in several jurisdictions the work load is so heavy that only part of the cases at a given level are processed. The usual way of handling the case surplus is to review all cases, act on the most serious ones, and route the less serious back to file. The study could not be carried out in such a jurisdiction because the control group would consist of less serious cases and would not be comparable to the experimental group. It is fortunate for this study that the case load in the New Jersey point system exceeds the number that can be processed, and, even more important, that the method of deciding *which* cases at 12 points will receive action does not involve reviewing the cases. Because of the existence of an adequate control group, New Jersey was selected as the jurisdiction in which to carry out this research.

In order to obtain a valid comparison, the experimental and control groups must be similar in all pertinent respects except receipt of action. There are two common methods of equating groups to meet these requirements. The first involves matching each driver in the experimental group with a control driver of the same age, sex, occupation, driving experience, accident and violation record, etc. The matching process is tedious and is feasible only with small samples of drivers and large amounts of time. The second method depends upon dealing with an entire population of drivers having certain characteristics (in this case a bad driving record) and assigning samples of the population to the experimental or control group in a random manner. If the assignment is random, it may be assumed that the groups differ only by chance in all respects except the variable under observation. The latter method was used in this study.

Collecting the Data

The information on which this study is based was taken from a case file containing records of drivers who reached 12 points and received departmental action, and a master file containing records of all drivers with one or more points who have not received action. Approximately 8,000 folders from the case file were screened and 2,400 were eliminated because the driver had received some other driver improvement action in addition to that under the point system (such as suspensions imposed by magistrates and revocations imposed under mandatory provisions of the law). The 5,600 remaining cases are records of drivers whose only contact with driver improvement was through the point system. In addition to these, the records of approximately 8,000 drivers were obtained from the master file. These records lay, without distinguishing marks, among nearly one million abstracts of conviction. To obtain these cases, (drivers who warranted but did not receive action) 183 of the 265 file drawers were searched. The term search is used in a literal sense because in order to locate the cases each had to be examined for point total and dates of violation. The information was gathered by more than 35 workers who devoted nights and weekends to this project over a ten week period.

Assumptions

In this study two basic assumptions are submitted to test:

1. It is proper to select drivers for departmental action on the basis of an accumulation of violations, because such drivers also have more accidents than average.
2. Departmental action is more effective than no action in bringing about desirable changes in the driver's behavior.

The first assumption is tested by observing the numerical relationship between certain convictions and reported accidents. The second assumption is tested by observing changes in the frequency and nature of subsequent violations committed by drivers who received action as compared to those who did not. Originally, it was planned to evaluate changes in the frequency and type of accidents as well, but a systematic error was discovered in the original information which introduced a bias and, most unfortunately, required discarding the accident data.

Accident-Violation Contingency

The first of the two basic assumptions is that drivers with violations on their records are more likely to have accidents than those with no violations. Previous studies have suggested a contingency between accidents and violations [1, 5, 8], but it is not clear whether they included controls for any of the factors which may cause spurious correlation. The first of these factors pertains to the kind of violations entering into the correlation. It often happens that a violation is charged as an outgrowth of an accident investigation. This results in the fact that any large group of drivers, each having several accidents, will have some violations on their record, if for no other reason than because of the charges filed at the scene of the accident. Such a correlation is of little value to driver improvement, because (1) the violation has no predictive value since it was charged after the accident, and (2) violations charged in accidents are only a small fraction of the total arrests which constitute the basis for driver improvement action. (In North Carolina only about ten percent of state highway patrol arrests are connected with accidents.) For these reasons it is probably more useful to observe the contingency between non-accident violations[1] and accidents. The question then becomes, "Do drivers who commit violations not connected with accidents also, on other occasions, tend to have accidents?"

[1]A non-accident violation is the typical situation in which the driver is apprehended and convicted for a moving traffic offense which did not occur in connection with an accident.

The second factor that tends to cause spurious correlation between accidents and violations is that of driving experience or age. Young drivers, who have been licensed only a short while, have not had time, as a group, to become involved in very many accidents *or* very many violations. On the other hand, older drivers, or drivers with many years experience, have had ample time to be involved in numerous accidents and violations. Extreme variation in age or experience may therefore cause an artificially inflated correlation. One way of checking the degree of this artificial correlation is to compare the accident-violation contingency of two groups of drivers, one having a wide range with respect to age and experience, and the other being more restricted in age and experience.

Figure 1 shows the contingency between accidents and violations taking into account the two factors mentioned. Only non-accident violations are used, and a group more restricted in age and driving experience is included as a comparison with the variant total sample. The information from which the graphs were made is shown in Table 1. It is obvious that there is a stable and substantial contingency between non-accident violations and accidents when dealing with the average record of a large group of drivers. The slope of the graph is not greatly different even when age and experience are restricted. At least one source of artificial correlation remains uncontrolled in that drivers with high exposure (high annual mileage) may have both more accidents and more violations than those with low exposure, and this would tend to make the slope steeper than if exposure were controlled.

The information used to show the accident-violation contingency was obtained by analyzing the records of more than 40,000 North Carolina drivers. The analyses reported in the remainder of the chapter are based on the research conducted in New Jersey.

TABLE 1
Average Accidents for Drivers with Various Numbers of Violations

Number of Non-Accident Violations	Drivers in Total Sample	Average Accidents Per Driver	Drivers Born in 1920's Licensed in 1947-50	Average Accidents Per Driver
0	29,984	.167	5,357	.279
1	5,921	.391	400	.435
2	2,221	.560	146	.548
3	1,042	.699	57	.825
4	595	.857	40	1.075
5	704	1.001		
Total	40,467		6,000	

Effects of the Advisory Notice

Ordinarily an advisory notice or letter is the first contact between the department and the driver who is beginning to build up a violation record. In New Jersey, for example, drivers who reach eight to 11 points were sent an advisory notice containing a request for their cooperation, a statement of their present point total, and a schedule of points. The letter in New Jersey, as in other jurisdictions, is sent in the hope that it will influence the recipient to drive more carefully and lawfully.

Little is known about the ability of a letter to control a driver's behavior, but the topic is most pertinent and at least one prior study has been carried out. The Texas Department of Public Safety recently completed two studies [6, 7], one concerning advisory letters and the other concerning re-examinations. In the first study, 100 drivers eligible for an advisory letter were selected from each of the four largest cities in Texas. Such a letter was sent to half the drivers from each city and was not sent to the other half. In the second study the same procedure was used but the letter was sent to drivers with a more severe record and required that they be re-examined. The records of these 800 drivers were kept under observation for approximately two years. The results of the study are presented in such a way as to permit computation of the percentage of drivers in each group who had subsequent accidents and violations. In each study the results are in the expected direction, but in only one is the difference large enough to be statistically significant. In the study of re-examinations, significantly fewer drivers who were re-examined had subsequent violations than drivers not sent examination letters. It is not clear, of course, whether the examination itself or mere contact with the department accounts for the differential improvement. Results derived from the Texas study are presented in Table 2.

The Texas study is commendable despite the fact that the results are less than startling. All the trends are in the desired direction, and indeed, if the same proportions held true in a larger sample, all the results would be statistically significant. The important thing about the Texas study is that the groups were set up in advance. This simple step eliminates the intricate and frustrating problems of sampling that were encountered in the New Jersey study to be reported. By establishing the control group in advance and setting the time period over which records are observed, most of the difficulties of after-the-fact research are eliminated. More will be said of this kind of study design at the conclusion of the chapter.

TABLE 2: Texas Department of Public Safety Study of Accidents and Violations After Two Types of Letters

	Drivers Sent Advisory Letter	Drivers Not Sent Advisory Letter	Drivers Sent Examination Letter	Drivers Not Sent Examination Letter
Number of Drivers	200	200	200	200
Proportion with Further Violations	.580	.625	.525	.690
Proportion with Further Accidents	.200	.265	.175	.250

The New Jersey study is similar to the Texas study in some respects and dissimilar in others. It is similar in that drivers who were and were not sent letters are compared in terms of subsequent violations. It is different in that the subsequent time period in the New Jersey study is not necessarily the same for each group. The practice of sending advisory letters in New Jersey was in effect for only eight months at which time personnel problems forced abandonment of the service. The letter group is drawn from those drivers whose record reached eight to 11 points during the period that letters were sent. The no-letter group is drawn from those drivers whose record reached eight to 11 points during the four months immediately before or immediately after the period during which the letters were sent. The average time at which the letters became due was about the same in each group. Since this is true, such things as fluctuation in enforcement stringency should affect both groups approximately equally. The New Jersey research, then, hinges on the comparison between two fairly similar groups, one sent letters and the other not.

Drivers who were sent letters may be divided into two categories, one consisting of those whose record subsequent to the letter continued to be so severe that further action had to be taken and the other consisting of those whose subsequent record improved to the extent that no further action was required. In terms of point accumulation, this

means that the first and by far the smaller group reached eight and went on to 12 or more points, and the other, probably constituting 80 per cent or more of those sent letters, reached eight but did not accumulate as many as 12. Each of these two groups is important to the overall study, and they should be combined and analyzed in their proper proportion. Unfortunately, however, they must be analyzed separately because of a sampling problem inherent in the after-the-fact nature of the research. The first set of comparisons concerns those drivers who reached eight points and did not go on to reach 12 points. These are presented in the most detailed form, because they are the most significant and concern the largest class of drivers. Since all these drivers showed enough improvement to avoid further trouble, whether sent a letter or not, the only way that the influence of the letter can be shown is through an even greater improvement in the subsequent record of the letter group than in that of the no-letter group. Such a comparison puts the letter to a most severe test.

Comparability of Groups Prior to Action

It is important that the letter and no-letter groups be compared with respect to their record up to the time of reaching the letter level. If the groups are substantially different *before* reaching letter level it would be impossible to know whether subsequent differences were attributable to the effects of the letter or to differences inherent in the groups prior to the time the letter level was reached. One way of comparing the letter and no-letter groups is to calculate the average number of points they had when they reached the letter level. Depending on the particular combination of violations that a driver commits, he could be sent a letter at eight, nine, ten, or eleven points. Two speeding convictions, for example, give a driver eight points and he would be sent a letter. If, however, he committed a speeding violation and then a stop sign violation, his point total would be seven and no action would be taken. If his next violation were speeding, he would then have eleven points and would be sent a letter. If the letter and no-letter groups are comparable, the average points at the time of reaching the letter level should be the same.

The 2,880[2] drivers in the letter group are compared to the 3,814 drivers in the no-letter group. At the time they reached the letter level the letter group had an average of 8.84 points, and the no-letter group had an average of 8.76 points. As is shown in Table 3, the averages differ by less than one-tenth of a point. Not only are the point totals similar, but the times at which the groups reached the letter level are very nearly the same. The month in which the average driver in the letter group was sent a letter was November, 1955, and the month in which the average driver in the no-letter group reached the letter level was January, 1956.

Another indication of the similarity of the letter and no-letter groups is the average number of points per violation committed prior to reaching the letter level. If points are scaled according to seriousness, the number of points per violation should give some indication of the severity of the violations committed. Table 3 shows that drivers sent letters were assessed an average of 3.84 points per violation, and drivers not sent letters received an average of 3.71 points per violation. These estimates were obtained by dividing the average number of points by the average number of violations. Obtaining the ratio of points to violations in this manner is not algebraically correct, but the particular way in which the information was gathered and arrayed on the punched cards makes it impossible to arrive at the ratio properly. This estimate is presented for what it may be worth.

The final comparison of prior records of the two groups concerns the *type* of violations committed. Chi square is used to test differences in the frequencies. The table also shows each violation frequency as a percent of the total. Table 4 shows that the letter and no-letter groups differ significantly, even before the letter, in terms of the frequency breakdown of the violations. The frequency of speeding violations, for example, is considerably more than expected in the letter group and considerably less than expected in the no-letter group. It is interesting to find that the two groups show significant[3] differences in the type of violation committed, even though the average points for each was very nearly the same. The number of observations makes the significance test very powerful, and relatively small absolute differences approach statistical significance. Considering all the comparisons, it seems that the groups are reasonably alike in terms of their need for driver improvement even though certain significant statistical differences appear. The nature of the differences is not such as to suggest that one or the other group would show a superior record subsequently.

Differences Subsequent to Action

If advisory letters produce any desired effects, fewer drivers sent letters should show subsequent violations than those not sent letters. Table 3 shows that only 12 per cent of drivers sent letters had further violations whereas 19 per cent of those not sent letters had at least one. Naturally, these values are partly dependent on the time period over which the violations were recorded. If one group was measured over a one year period and the other over a two year period, the latter probably would show more violations simply because a greater time period was involved. Since the present study was not a controlled experiment, set up in advance, the time period for each group is not the same though fortunately the averages are nearly equal. The average time over which the letter group was observed was 22 months as compared with 20 months for the no-letter group. The significance[4] of the superiority of the subsequent record of the letter group is underscored in view of the fact that relatively fewer violated despite a somewhat longer time period. Among drivers who reached eight but not 12 points, it appears that the letter reduces by almost half the per cent of drivers who would otherwise commit an additional violation. Note that the reduction in violations in the control group is rather marked. This

[2] The reader will note throughout the article that the sample size of a given group varies from one analysis to the next. There are two reasons for this variation. First, some punched cards were discovered to be partly incorrect and were therefore eliminated from some analyses. Second, some cards became worn, jammed in the machine, and were destroyed as the analysis proceeded. There is no reason, however, to assume that any systematic error is introduced by these slight variations in sample size.

[3] $X^2=87.6$ ($p<.01$).

[4] The critical ratio of the difference between proportions is 8.33 ($p<.01$).

TABLE 3: Subsequent Violations of Drivers Sent Letters and Drivers Not Sent Letters

	Number of Drivers	Average Points Before Letter	Average Length Post Letter Period	Proportion with Subsequent Violations	Points Per Violation Before Letter	Points Per Violation After Letter	Lapse Between Letter and Next Violation for Drivers with Subsequent Violations
Drivers Sent Letters at 8 Points	2,880	8.84	22	.117	3.84	3.71	M=10.0 s=6.11 N=317
Drivers Not Sent Letters at 8 Points	3,814	8.76	20	.192	3.71	3.60	M=8.7 s=6.5 N=720
				CR=8.33 p<.01			CR=3.03 p<.01

TABLE 4: Frequency of Various Types of Violations Prior to Reaching Letter Level

Violation	Drivers Sent Letters			Drivers Not Sent Letters	
	Observed Frequency	Observed Per cent	Expected Per cent	Observed Per cent	Observed Frequency
License or Restriction	13	0.4	1.5	2.2	85
Equipment	4	0.1	0.4	0.6	23
Traffic Control	208	7.2	7.9	8.4	319
Passing	40	1.4	1.6	1.8	68
Lane Travel	41	1.4	1.5	1.6	60
Others	22	0.8	0.9	1.1	40
Careless Driving	170	5.9	7.3	8.4	317
Speeding	2,263	78.3	73.6	70.1	2,655
Reckless Driving	55	1.9	2.1	2.2	85
Leaving Scene	73	2.5	3.1	3.6	137
Total	2,889	99.9	99.9	100.0	3,789
X^2>85.0		df=9		p<.01	

is probably partly regression to the mean (a rather low mean—only about seven per cent of New Jersey drivers violate each year) and partly a result of other deterring factors.

Despite the influence of the letter and other deterring factors, 12 per cent of drivers sent letters and 19 per cent of drivers not sent letters show further violations. The letter appears, however, to influence even those that violate subsequently by delaying the onset of the violation. Considering only the 400 drivers who committed violations after being sent a letter and the 700 who committed violations but did not receive such a letter, the average lapse between the time of reaching letter level and the next violation was computed. For those sent a letter, the lapse is 10.0 months and for those not sent a letter, the lapse is 8.7 months. The lapse following the letter is significantly[5] greater than in the cases in which no letter was sent.

Differences Independent of Action

Though the letter is the variable operating differentially, there are other deterring forces operating in both groups. Drivers in both groups had to pay fines, perhaps endure censure, etc. If this is true, drivers not sent letters should show improvement as time, fines and censure go on. Two comparisons suggest that this is true. As was mentioned earlier, drivers not sent letters had an average of 3.71 points per violation, but later, though no letter was sent, the average number of points per violation was found to be 3.60. If the average number of points received for each violation decreases, then it must be true that high-point-value-violations (more serious ones) were committed relatively less often later than they were earlier. This hypothesis can be tested by studying the no-letter group with respect to the type of violation the group committed as their first offense and the type committed subsequent to reaching the letter level (ordinarily their third or fourth violation). Table 5 shows that speeding, reckless driving, and leaving the scene of an accident are committed relatively more frequently as first violations than they are as later violations. Naturally, if the percentage of these decreases as time goes on, something else has to increase since total violations must still add up to 100 per cent. It is found that the increase is distributed over several violations generally of a less serious nature, and the changes are very significant.[6] Very similar changes were found in the letter group by comparing the first violations committed with the ones committed immediately after the letter was sent.[7] It is evident that (1) the type of violations committed changes significantly as the driver continues to violate, (2) the nature of the change does not appear to be related to receipt or non-receipt of the advisory letter, and (3) changes are in the direction of less serious violations. *These* changes seem logical, but some others are not so readily explained. It is found that the letter and no-letter groups differ significantly in terms of the type of violations they committed first (see Table 4), each undergoes significant changes as the violation sequence develops, and finally, after reaching the letter level, they are more similar than they were earlier. The meaning of these latter changes is not clear, but they are interesting to note.

Drivers Who Eventually Reached Suspension Level

The foregoing comparisons pertained to drivers who reached the letter level and, though they may have received *some* additional points, did not reach suspension level. Most drivers who accumulate enough points to warrant a letter fall into this category, but a few (usually not more than 10-20 per cent) continue to accumulate points until they reach suspension level. The records of such drivers were subjected to the same analyses as those just reported.

[5]Critical ratio equals 3.03 (p<.01).

[6]Chi Square equals 190.

[7]Note that in this and succeeding tables the assumptions of independence inherent in the use of Chi Square are not met. It is likely however that the resulting error results in an *underestimate* of the true significance (See Appendix 1).

TABLE 5: Frequency of Various Types of Violations Among Drivers Not Sent Letters

Violation	First Violation			Third Violation	
	Observed Frequency	Observed Per cent	Expected Per cent	Observed Per cent	Observed Frequency
License or Restriction	85	2.2	2.3	2.7	20
Equipment	23	0.6	0.9	2.2	16
Traffic Control	319	8.4	9.6	15.7	117
Passing	68	1.8	2.4	5.7	42
Lane Travel	60	1.6	1.9	3.4	25
Others	40	1.1	1.3	2.8	21
Careless Driving	317	8.4	9.2	13.3	99
Speeding	2,655	70.1	67.3	53.4	397
Reckless Driving	85	2.2	2.0	0.7	5
Leaving Scene	137	3.6	3.0	0.1	1
Total	3,789	100.0	99.9	100.0	743
$X^2 > 190.0$		df=9		$p < .01$	

In a sense such drivers are, by definition, those who are not deterred by the various forces of society, therefore, it should not be surprising to find that receipt or non-receipt of an advisory letter has no appreciable influence on the nature or severity of their subsequent records. The only significant finding is that drivers who were sent a letter and went on to suspension violated sooner than drivers not sent a letter who went on to suspension. Advisory letters show appreciable effects on the 80-90 per cent of drivers who reach letter level but do not become real problems, but show little influence on the small proportion who continue to violate. It is gratifying to find that advisory letters are the most effective with the largest class of drivers and that action at suspension level has desirable effects on those few drivers who are apparently insensitive to other deterrents.

Summary of Findings

Comparison is made between two groups of drivers, all of whom reached eight points and none of whom went on to reach suspension level (12 points). One group was sent advisory letters at eight points and the other was not. After establishing comparability of the groups with respect to prior record, it is shown that fewer drivers sent letters have subsequent violations than those not sent letters. The letter is shown to influence even those who *do* violate subsequently in that the lapse between the letter and the next violation is longer than the comparable period in the no-letter group. Both the letter and the no-letter group showed significant changes in the type of violation committed third in series compared with those committed first. The changes are in the direction of less serious violations and do not appear to be influenced by receipt or non-receipt of an advisory letter. The smaller group of drivers who go on to suspension level was, of necessity, analyzed separately and does not appear to be influenced by the letter (at least not desirably influenced).

Discussion of Results

It is clear that the advisory letter induces desirable changes in the behavior of many of its recipients. Some readers may be disappointed to find that letters are no more effective than to reduce 19 per cent violations to 12 per cent, but perhaps further consideration will change that somewhat. By extrapolation of the New Jersey results onto a larger scale it is possible to see that small differences in effectiveness of a technique affect large numbers of drivers on a continent-wide basis. Suppose that there are 85 million drivers in the United States and Canada and that letters are sent in all jurisdictions in the proportion found typical in point system jurisdictions. This would mean that about 850,000 letters per year would be sent. Since other evidence indicates that only about 15 per cent of drivers go on to suspension level after receiving a letter, it would seem that 85 per cent or 722,500 drivers would fall into the category of drivers studied in New Jersey. If the New Jersey results are applied to this number, it would be supposed that 19 per cent of the total would violate subsequently. Nineteen per cent of 722,500 amount to 137,275 drivers. If 12 per cent would violate after receiving the letter, the number would be 86,700. The difference between these two numbers is more than 50,000 which indicates the number of drivers that would be deterred each year by full use of the advisory letter. To carry this fanciful example one step further, suppose that through refinement of the letter it was found that 11 per cent violated subsequently instead of the present 12 per cent. The one per cent difference would involve more than 7,000 drivers each year, which means that adoption of such an improved letter for three years would affect more than 20,000 drivers. Everyone realizes that extrapolation of such figures is fraught with error, and it is not the intention in this illustration to estimate the number of drivers influenced by the letter. **It is important, however, to emphasize the fact that small increases in the effectiveness of driver improvement practices will influence large numbers of drivers each year and when such improvements are carried over a period of years the results are staggering to the imagination.** There is little validity to arguments that small scale refinements in driver improvement are not worthwhile.

In addition to preventing violations, there is evidence that the advisory letter tends to delay the onset of the violation in those who do violate. A most interesting study could be carried out which would consist of sending a group of drivers a friendly, semi-congratulatory letter about six months after the advisory letter, provided that there had been no further violation. Such a letter might bolster the waning effects of the advisory letter and prevent the onset of the violation even further. If proper controls were established and the results were carefully documented, it is possible that a powerful and worthwhile means of influencing drivers would emerge.

Another interesting finding is that the type of violation committed undergoes significant change as the driver continues to violate. This finding also indicates that when the forces of society fail to control the behavior of a driver, they do not fail completely. Such drivers continue to violate, but they apparently commit less serious violations (if the reader grants that violations with lower point values are generally less serious). From this initial study it is not possible to know whether changes in violation type over a period of time are the result of changes in individual drivers or changes in the constituency of the group. It is possible that changes in the type of violation committed first as compared to those committed third exist only because many drivers present in the earlier group are absent from the later (because they did not continue to violate).

Thus, drivers who have three violations may, as a group, commit the same type third as they did first, but, whereas they constitute the entire group with three violations, they are only a small part of the group with one violation and may be "drowned out" by the drivers whose one violation is different in nature. These interesting side lights could be explored in further research.

The study of advisory letters in New Jersey produced several satisfying and provocative findings. In addition to the specific results, the findings indicate that the next step is to carry out a thorough study of the effects of various types of letters, sent at various levels. Such research should furnish means of obtaining the best use of letters. It is quite possible that one type of letter is distinctly better than another, and it is also possible that letters are more effective at one point level than another. It is obviously to the administrator's advantage to find the level at which the effectiveness of the letter is maximum. Of course, he must consider both the expense involved and the degree of influence on the driver. In order to carry out this type of investigation, it would be necessary to establish groups and introduce controls in advance. After-the-fact research like the New Jersey study is a satisfactory prelude for controlled experimentation but is no substitute for it. Controlled experimentation takes more time than after-the-fact research, and when time means lost lives it is tempting to take the shortest course. Indeed, in the present study it was necessary to carry out the various projects after-the-fact despite a two-year schedule. It may be disturbing to contemplate, but it is true that a five-year program of controlled experimentation will yield more usable information than could be obtained from a series of shorter, after-the-fact researches.

Conclusions and Recommendations

The advisory letter appears to prevent violations in many drivers, delay violations in some and have no effect on others. It influences more drivers than it fails to influence, however, and should be used universally as a part of driver improvement. Advisory letters should be studied further by systematic experimentation in order to improve the contents of the letter and determine the best level at which letters should be sent. Also worth study is the idea of a follow-up letter which is, in effect, a commendation. Such a program of study would permit improvement of the effectiveness of advisory letters, and even slight improvement will affect additional thousands of drivers on a continent-wide basis.

Effects of Action at Suspension Level

When a driver's record reaches a certain level of severity, the department ordinarily initiates action which leads to suspension of the driver's license or takes other appropriate action. In New Jersey, drivers who accumulate 12 points in three years are sent a notice stating the department's intent to suspend. The notice informs the driver that he may request a hearing, and if he does so the suspension is stayed pending the outcome of the hearing. If the driver does not request a hearing, suspension goes into effect shortly thereafter. Many drivers request a hearing, and after the hearing their license may be suspended or they may be placed on formal or informal probation. Presumably, each action has its own ability to improve the driver's behavior, and each driver has his own individual characteristics which make him more responsive to some kinds of action than others.

As was the case with advisory letters, little research has been conducted to determine the influence of departmental action. With the exception of the Texas study cited earlier in the article, most previous studies of departmental action have been carried out after-the-fact. A study carried out by the California Motor Vehicles Department [4] compares drivers before and after an interview. A very old study done in Wichita, Kansas [8], compares the subsequent records of drivers receiving various actions. Both studies are difficult to interpret because they lack a control group. The latter, however, has a number of groups whose members received one of several kinds of action (arrests, warnings, traffic violator schools, etc.). The Wichita study showed that fewer drivers violate subsequent to attending a traffic violator school than subsequent to an arrest or warning but does not deal with comparability of the groups prior to action.

In the present investigation, seven groups are studied including six experimental groups and a control group. These groups, separately and in combination, are compared with respect to frequency and type of violation committed before and after departmental action. The groups are defined in the following outline:

I. Drivers Sent Hearing Notice At 12 Points (experimental group-total 4,600 drivers).
   A. Ignored notice
      1. received short suspension (default-short suspension group includes 475 drivers).
      2. received long suspension (default-long suspension group includes 625 drivers).
   B. Attended hearing
      1. were suspended
         a. short suspension (hearing-short suspension group includes 1,750 drivers).
         b. long suspension (hearing-long suspension group includes 675 drivers).
      2. were placed on probation
         a. formal probation (formal probation group includes 825 drivers).
         b. informal probation (informal probation group includes 825 drivers).

II. Drivers Not Sent Hearing Notice At 12 Points (control group-total 3,100 drivers).
   A. Have subsequently received action (case file sample-total 1,175 drivers).
   B. Have not subsequently received action (master file sample-total 1,950 drivers).

There were a number of sampling problems connected with obtaining an adequate control group and they are discussed in Appendix One.

Comparability of Groups Prior to Action

In order to be able to interpret post-action differences between groups, it is necessary to have some idea of their pre-action similarity. The first indication of group comparability is the average number of points each had when they reached suspension level. The combined experimental group had an average of 13.20 points when action was taken and the combined control group had an average of 13.04 points when they became eligible for action. The

difference is less than two-tenths of a point with the control group having slightly the better record. Though such a slight difference has little practical significance, the difference is statistically significant[8] due to the extremely large samples. Since, however, the control group shows a slightly better prior record than the experimental group, the difference is in the least objectionable direction, because in order to show subsequent superiority the experimental group must improve even more than the control group.

When the experimental groups are broken down according to type of action received, a number of interesting differences is seen. Table 6 shows that the average points at action level vary from 12.71 per driver in the informal probation group to 13.74 for drivers in the hearing-long suspension group. Virtually all of the measures are significantly different from the control group and from each other. It seems obvious that the number of points on a record is at least one of the factors determining the type of action taken. Drivers given long suspensions at the hearing had an average of 13.74 points and those given short suspensions had an average of only 13.18 points. These two figures differ to a highly significant degree. The same trend holds true for those who defaulted and were given short or long suspensions. It thus appears that, from a large population of drivers, those with more points tend to get longer suspensions. To carry the speculation further, it appears that drivers placed on informal probation may have received that action, because as a group they had fewer points (12.71). The group placed on formal probation, however, had an average as high as some of the groups receiving suspension. Formal probation represents a compromise between the severity of their record and extreme need for the license and is granted at the discretion of the hearing officer.

The differences in the prior point level of the groups probably do not bias the data, because the subsequent violation record does not appear to be related to the specific point level reached before action was taken. Several groups, separately and in combination, were divided according to the point level at which action was taken. It was found that drivers received the various actions at 12, 13, 14, 15, or 16 points. There were no trends observed in the proportion violating subsequently. Those suspended a given length of time at 16 points violated no more or less often than those suspended the same length of time at 12 points. Another comparison that is relevant to comparability of the groups is the average date that they reached action level, and this information is also in Table 6. The month in which the average case in each group reached action level falls within the eight month period beginning January, 1956. This means that gradual changes in such factors as enforcement policy should affect the groups to a similar extent. Each month listed in the table is an average, and the drivers within each group are scattered about the average. Note that both of the short suspension groups have an earlier average date than either of the long suspension groups, reflecting perhaps a recent tendency to impose longer suspensions than has been the practice in the past.

A final check on the similarity of the groups prior to action is made by comparing the types of violations each group committed prior to action. Table 7 shows the data for a comparison of frequencies, and violation type is significantly[9] different for the two groups. Strangely, the significance is due to one violation, that being equipment (muffler violations mostly), and without it the groups would not have differed significantly. Why the experimental group should have fewer than expected muffler violations is not known, but at any rate the overall difference between violation types does not seem to be great or to show meaningful trends.

TABLE 7: Violation Type Before Action—Experimental and Control Groups

Violation	Combined Experimental Group			Control Group	
	Observed Frequency	Observed Per cent	Expected Per cent	Observed Per cent	Observed Frequency
License or Restriction	195	4.2	4.4	4.5	143
Equipment	18	0.4	1.0	2.0	63
Traffic Control	511	11.1	11.5	12.1	381
Passing	143	3.1	3.2	3.3	104
Lane Travel	79	1.7	1.8	1.9	59
Others	109	2.4	2.5	2.8	88
Careless Driving	540	11.7	12.1	12.7	401
Speeding	2,754	59.8	58.5	56.6	1,780
Reckless Driving	184	4.0	3.5	2.7	86
Leaving Scene	73	1.6	1.5	1.3	41
Total	4,606	100.0	100.0	99.9	3,146
	$X^2 > 60.0$		df=9	p<.01	

The prior records of the groups are dissimilar in some respects. Apparently one reason for their difference is that action was determined on the basis of the prior record. The size of the pre-action differences is small, however, and the nature of the differences does not suggest a predisposition of one group or the other to show a certain kind of subsequent record; therefore, the groups are thought to be sufficiently similar to permit interpretation of

[8]Critical ratio 5.52.

9. Chi Square greater than 57.

TABLE 6: Average Points at the Time of Action for Several Experimental Groups and the Control Group

	Groups							
	Combined Experimental	Control	Default		Hearing		Probation	
			Short Susp.	Long Susp.	Short Susp.	Long Susp.	Formal	Informal
Average Points	13.20	13.04	12.73	13.56	13.18	13.74	13.56	12.71
Standard Deviation	1.29	1.13	1.03	1.30	1.23	1.41	1.39	1.22
Average Month Case Reached Action Level	——	June 56	Jan. 56	Apr. 56	Jan. 56	Apr. 56	Aug. 56	Mar. 56
Number Drivers	4,516	2,760	487	599	1,735	651	230	814

subsequent differences as being a product of the action received.

Differences Subsequent to Action

There are many large and reliable differences among the subsequent violation records of groups receiving various actions from the department. Table 8 lists several comparisons, and many more may be computed from the information therein. The second row of figures shows the proportion of drivers in each group who violated subsequent to action. These figures, however, cannot be compared directly, because they are based on substantially different periods of observation. Note, for example, that the observation period for group three (the default-long suspension group) is less than ten months, and the period for group four is more than 15. While the proportion of drivers violating is almost the same (.216 against .207), it is obvious that a given proportion represents worse driving if a shorter time period is involved. In view of the variation in time periods, it is necessary to correct the original proportions to account for this variation.

The observation period for each group is determined by computing the month in which the average case reached action level and finding the length of time between that month and September, 1957. September, 1957 is the month in which information was gathered and, since entries on the record subsequent to that time are not included, that month is the cut-off point of the study.

Table 6 showed that the average case in the hearing-long suspension group was acted on in April, 1956. These drivers, then, could have committed a violation subsequent to action any time from April, 1956 to September, 1957, a period of about 16⅔ months. This is not, however, the figure indicated as the period of observation in Table 8. The reason for this is that the drivers involved actually were not able to drive all of that time, because for at least part of the time their license was suspended. To obtain the final figure for the period of observation, the length of time without a license is subtracted from the first figure. For this particular group the length of time without a license was 6.8 months (this figure includes the actual suspension plus any delay in reinstatement due to difficulties in securing insurance, etc.). Subtracting 6.8 from the original period gives 9.87 months (shown in Table 8), which was the period during which the drivers could drive legally. These computations bear the implicit assumption that driving while under suspension is negligible.

Before comparison is made the original proportions are adjusted by increasing or decreasing the value to a 12 month period. Thus, if 30 per cent of the drivers violate in 15 months, it is assumed that two per cent violate each month and that the 12 month figure would be 24 per cent. It is difficult to decide which constitutes the least objectionable alternate, that of having varying periods of observation or that of altering the proportions to correct for time. Though the time-corrected proportions are the basis of the comparisons litsed, the original proportions are included and may be compared. The significance of most of the comparisons is the same regardless of which of the sets of data are used, but there are a few important differences.

The most striking features of the data as analyzed are the large and reliable differences between the control group, the combined suspension groups, and the combined probation groups. The control group shows 37 per cent with further violations, the combined suspension groups 22 per cent, and the combined probation groups 10 per cent. These differences are statistically significant and are considerable in size. Drivers not receiving action show a much higher rate of violations than do drivers receiving some kind of driver improvement action. In addition to these findings, the usefulness of probation as a driver improvement tool is confirmed. This is shown by the fact that significantly fewer drivers violate after probation than after suspension. It is impossible from these results, however, to know whether the superior showing of drivers on probation is due to inherent properties of that driver improvement method or the fact that the hearing officer is a good judge of the type of driver that will respond to such handling.

TABLE 8: Proportions of Drivers with Violations Subsequent to Various Kinds of Action

Comparisons			
Groups	Critical Ratios	Groups	Critical Ratios
1 vs 3	4.64*	4 vs 6	2.04
1 vs 5	0.54	6 vs 7	0.58
1 vs 6	7.78*	1 vs 2-3-4-5	4.07*
2 vs 3	2.71	2-3-4-5 vs 6-7	8.63*
2 vs 4	1.61	2-4 vs 3-5	10.00*
3 vs 5	3.53*	2-3 vs 4-5	1.07
4 vs 5	10.27*		

*p<.01

The results also show that more drivers violate subsequent to a long suspension than to a short suspension. On the basis of available information it is impossible to know whether these results are due to the length of suspension itself or to the fact that the worst drivers are given the longest suspensions, and after reinstatement they continue to be the worst drivers. Another comparison indicates that there is not a significant difference between the proportions violating after a suspension by default or a suspension after a hearing. This is hardly a confirmation of the wide belief that it is better to suspend a driver after talking to him than to suspend him by mail. No firm conclusion can be reached, however, because it happens that the prior record of the group requesting the hearing was slightly worse than those defaulting (taking average points as the criterion), and the proportion violating subsequently was slightly greater. There is no indication that subsequent record is dependent on number of prior points, but it is not within the power of this study to settle this important question. A similar set of circumstances is encountered in comparing formal and informal probation. The difference between the proportion violating after formal or informal probation is not significant; however, those placed on formal probation had worse prior records (higher average points) and may, therefore, have shown more improvement, even though the results do not indicate that possibility.

As in the analysis of advisory letters, there is a possibility that receipt of action has some influence even on drivers who violate subsequently. Drivers who violated subsequent to action in the combined experimental groups

were compared to control group drivers with subsequent violations with respect to the lapse between receiving action (or reaching action level) and the next violation. It was found that experimental group drivers who violated subsequently waited an average of 7.6 months before violating. Control drivers who violated waited an average of 6.3 months. The difference was significant.[10] Note that the lapse for both groups is shorter than the comparable lapse at the eight point level, though the size of the difference is the same.

Changes in Type of Violation

Significant changes occur in the type of violation committed as the sequence of violations develops. Changes occur regardless of the action received and, in fact, occur *whether or not* action was received. The basic nature of the change seems to be that drivers who have several violations tend to commit less severe violations as time goes on. An indication of this decrease in severity can be obtained by comparing the points per violation early in the violation history with the points per violation later. Table 9 shows that there is a decrease in points per violation in all cases, which presumably indicates a decrease in severity since the worst violations carry the most points. Remember that the values of points per violation were obtained in an algebraically incorrect manner, and one should not expect too much from them.

The indicated decrease in severity is confirmed by an analysis of the types of violations committed early and late in the violation history of the driver. Speeding and reckless driving constitute a much lower than expected percentage of the total *after* action. Other violations have to replace those that decrease—the total still has to add 100 per cent —and increases are observed in such things as violations of traffic controls and careless driving violations. Table 10 shows changes in frequencies for the probation and suspension groups, and these changes are typical of those in the other groups.

10. Critical Ratio greater than 4.0.

TABLE 9: Points Per Violation Before and After Action for Several Groups

	Groups						
	Control	Default		Hearing		Probation	
		Short Susp.	Long Susp.	Short Susp.	Long Susp.	Formal	Informal
Points Per Violation Before Action	3.68	3.86	3.74	3.77	3.82	3.72	4.54
Points Per Violation After Action	3.50	3.53	3.44	3.35	3.28	3.58	3.26

Summary of Findings

The total experimental group was found to differ slightly from the control group in number of points prior to action, but it was the experimental group which had the more severe prior record, which makes their subsequent superiority even more significant. When the experimental group was broken down according to type of action taken, the groups were found to differ from one another in a significant degree indicating that the kind of action taken was partly dependent on the point score at that time. Drivers given long suspensions, for example, had more points as a group than drivers placed on probation. The comparability of groups prior to action was further examined by calculating the month that the average case reached action level, and all groups fell within the period January-August, 1956. Also, the frequency of various violations committed prior to action by each group was similar except for a curious, unexplainable difference in equipment violations.

Many very significant changes in the record followed the receipt of driver improvement action. Far fewer drivers placed under suspension violated subsequently than did

	Groups						
	Control	Default		Hearing		Probation	
		Short Susp.	Long Susp.	Short Susp.	Long Susp.	Formal	Informal
Number Drivers	2,769	489	628	1,752	694	232	826
Proportion with Subsequent Violations	.451	.182	.216	.207	.291	.116	.145
Average Length Post-Action Period	14.80	11.19	9.83	15.13	9.87	12.36	17.39
Proportion with Subsequent Violations-Time Corrected to 1 year Period	.366	1.95	.264	.164	.354	.113	.100
		.234		.218		.103	
		.223					
Group Number	1	2	3	4	5	6	7

drivers in the control group. Also, drivers placed on probation showed a better subsequent record than those suspended. Fewer drivers given short suspension violated subsequently than was the case with those given long suspension. No differences were found in the subsequent records of drivers given formal or informal probation, but the former had a worse prior record. Similarly, drivers suspended by default were not different from those suspended after hearing, but the latter had a more severe prior record. There was no indication, however, that severity of prior record, as such, influenced subsequent violation record.

Violation	Combined Experimental Group Before Action (1st & 2nd Violation) Observed Frequency	Observed Per cent	Expected Per cent	Combined Probation Group After Action Observed Per cent	Observed Frequency
Traffic Control	1,005	11.4	11.6	19.2	29
Other	728	8.3	8.3	7.9	12
Careless Driving	1,104	12.6	12.7	17.2	26
Speeding	5,566	63.4	63.2	51.7	78
Reckless Driving	372	4.2	4.2	4.0	6
Total	8,775	99.9	100.0	100.0	151
	$X^2=13.5$		df=4	p<.01	

TABLE 10: Frequency of Various Types of Violations Before and After Action

Violation	Combined Experimental Group Before Action (1st & 2nd Violation) Observed Frequency	Observed Per cent	Expected Per cent	Combined Short Suspension Group After Action Observed Per cent	Observed Frequency
Traffic Control	1,005	11.4	11.4	11.3	17
Other	728	8.3	8.4	16.0	24
Careless Driving	1,104	12.6	12.7	20.0	30
Speeding	5,566	63.4	63.2	49.3	74
Reckless Driving	372	4.2	4.2	3.3	5
Total	8,775	99.9	99.9	99.9	150
	$X^2>21.0$		df=4	p<.01	

After-the-Fact Research and Its Alternate

It has been mentioned that after-the-fact research is adequate for showing gross changes, but it can only be regarded as a prelude to controlled experimentation. Some of the problems encountered in the New Jersey study would be avoided in a study in which the groups were set up in advance. Such experimentation takes time, and the very urgency of time often results in resorting to after-the-fact research. Objections may be voiced to "experimenting with human lives," but these objections can be met by proceeding carefully. No driver need be callously handled for the sake of experimentation. Even if such were necessary, it would seem that a clearer conscience would be justified than is the case now upon considering that many drivers die each year because such experimentation has not taken place and thereby has not resulted in the refinement of techniques to the degree of maximum ability to influence dangerous drivers. The task of carrying out such experimentation will no doubt be difficult, time-consuming, and expensive, but the fruits of the study could help to guide the development of driver improvement with fact instead of speculation. After-the-fact research has quite satisfactorily served a purpose in showing the grosser influences of driver improvement, but now it is necessary to deal more precisely with the elements of causation, and this can be done only through controlled experimentation.

Conclusions and Recommendations

It is most obvious that driver improvement justifies its existence by clear demonstration of its ability to influence drivers' behavior. Further investigation is recommended for the purpose of determining methods of refining techniques. In the meantime, the use of standard driver improvement practices is recommended.

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Appendix 1

The New Jersey study is quite complex in terms of sampling procedures and adjustments of the control group but is fairly simple and straightforward in terms of statistical methods. The experimental design consists of comparing various groups with respect to post-action violation records after having ascertained the degree of their pre-action similarity. The dependent variables include proportion of drivers with post-action violations, length of time between departmental action and the next violation, and percentage breakdown of violation types.

Statistical Methods

The post-action records of various groups are compared through use of the critical ratio of the difference between proportions, the critical ratio of the difference between means. Comparisons of proportions always involved independent proportions and the formula shown in McNemar[11] was used. The correction for continuity was not included in the computations because the proportions were not extreme and the Ns were large. When the test is the critical ratio, the null hypothesis is rejected when p is less than .01 for a two-tailed test.

Chi Square was used in several places to test the null hypothesis that violation types occurred with equal frequency in two situations. Most of the uses of the test in this study fail to meet one of the assumptions of Chi Square —independence. While it is true that the violation categories are independent, in several cases the groups are *not* independent because two separate observations are made on the same individuals (See Lewis and Burke[12]). This situa-

[11]McNemar, Quinn, *Psychological Statistics*, John Wiley and Sons, New York, 1955, p. 60.

[12]Lewis, Don, and Burke, C.J., "The Use and Misuse of the Chi Square Test," *Psychological Bulletin*, 1949, 46, pp. 433-489.

tion arose because the analysis of violation types was not planned in advance (This promising line of investigation was noted rather by chance.), and the data were not gathered so as to permit an adequate analysis. It is felt, however, that the statistic obtained is a *conservative* estimate of the true significance, and the results are therefore included. The results are felt to be conservative, because it seems almost certain that the variance of the occurrences *within* a sample is less than that between samples, and the distribution of Chi Square is based on such between-sample variance.

Adequacy of the Control Group

It is important that the operations be described by which the control group came into existence, because unless it can be assumed that the control group constitutes an adequate basis for comparison, the study is limited. In New Jersey, all drivers who accumulate 12 points in three years are supposed to receive action, but the fact is that some do not. The factor that causes this situation is the hearing officers' backlog. During periods of normal functioning, the records of all drivers who reach 12 points are removed from the master file and designated for action. After a few weeks of such procedure, however, a surplus of cases is built up, and hearings are scheduled far in advance. This happens because the daily rate at which cases reach the 12 point level is greater than the daily rate of disposition of cases. When the surplus grows to a certain size, the point system is "turned off" until the surplus is dissipated. (Note: Since release of this study this practice has been eliminated.) During the period of non-operation, no cases reaching 12 points are removed and designated for action, but rather all are left in the master file. Once the surplus is dissipated, the normal procedure of removing cases resumes.

Drivers whose records reached 12 points during the time the point system was "turned off" are not designated for action and have "escaped" action at least temporarily. Such drivers are still subject to action, however, and if they commit a further violation, they will probably be designated for action. Such a case would be handled no differently from the ordinary 12 point case except that the point total would be higher (perhaps 16 or more). On infrequent occasions it happens that a driver is passed over twice. That is, his case reaches 12 points, he is passed over, commits another violation and is passed over again.

The control group, then, includes three types of drivers, all of whom were originally passed over when they reached 12 points:

1. Drivers who reached 12 points, were passed over, and have committed no further violations (such drivers have not received departmental action).
2. Drivers who reached 12 points, were passed over, committed another violation, and were passed over again (such drivers have not received departmental action).
3. Drivers who reached 12 points, were passed over, committed another violation, and were designated for driver improvement action.

To be representative, the control group must include each of the above three types of drivers in the proportions in which they occur in the population. This poses a difficulty because the proportion in which they occur cannot be rationally determined. Considering, however, the low probability of violations and the phenomenon of regression to the mean, it can be deduced that Group One is the largest, Group Three the next, and Group Two the smallest.

The actual records of drivers in the three control subgroups are scattered among two files. The first, containing most of the control group cases, is the master file. Because of the periods of non-operation, the master file contains the records of drivers who have reached 12 points, have been passed over, and have not received departmental action. Thus, Groups One and Two from above are in the master file. The second file is the case file, which contains records of all drivers who have received departmental action under the point system. Most of the records in this file belong in the experimental group, but a few are records of drivers who reached 12 points, were passed over, committed another violation and eventually received action. These control group cases are those in Group Three above.

The control group must include drivers who did violate as well as those who did not violate subsequent to the time action was due. If, for example, only case file drivers were used as the control group, the subsequent records would look too "bad" because 100 per cent of these drivers had subsequent violations. If only the master file were used, the control group would look too "good" because most of these drivers did *not* have subsequent violations. The obvious solution to the problem is to compose the control group of *all* drivers who were originally passed over, regardless of the file in which their records are stored, because in this manner the groups would be combined in their natural proportion. Unfortunately, this solution would require a complete search of both files, a task beyond the resources of this study. It was possible to search the entire case file and thereby to obtain the entire population of control drivers in that file, because it contained only about 10,000 current cases, but the master file, containing nearly one million cases, could be only partially searched. The partial search of the master file included 183 of 265 file drawers. Each of these randomly selected drawers was searched completely, and they constituted 69 per cent of the total file.

Unweighted combination of *all* case file components of the control group with only 69 per cent of the master file components would bias the results by making the control group appear to be worse than it actually is. In order to obtain the best estimate of the control group, two assumptions are made to compensate for these sampling difficulties. First, it is assumed that the drivers passed over are scattered evenly throughout the master file and that, therefore, searching 69 per cent of the files yielded 69 per cent of the total control drivers. (Since the drawers were selected randomly, and the records are filed alphabetically, it is assumed that the sample is representative of the total.) Second, it is assumed that the best estimate of the proportion of drivers violating subsequent to the time they reached action level (and were passed over) would be obtained by combining the master file sample (69 per cent of the population) with 69 per cent of the case file population.

The question of whether or not indicated differences can be assumed to reflect true differences hinges on the question of whether or not the control group, as constituted, actually represents an adequate base against which the experimental groups may be compared. Despite extensive sampling problems, it seems likely that the control

group is usable, though not as precisely determined as is desirable. Fortunately, the magnitude of post-action differences between experimental and control groups is large, which indicates that differences would still have been significant had the control group shown a considerably better record than it did. This is mentioned because the apparent severity of the control group's record is dependent on the characteristics of the drivers who escaped action and are in the unsearched part of the master file. If the number obtained in the 69 per cent of the master file grossly underestimates the number in the total file, the control group is better than it appears to be, thus the differences between it and the experimental group are less. This seems unlikely to be the case, however, due to the fact that *most* of the file was searched.

Treatment of the Data

Since data collection began shortly after September 1, 1957, only violations occurring before that time were considered. For each group, the month in which action was taken toward the average case was computed. The difference between this value and September 1, 1957, was the average number of months of "post-action" driving time. Of course, drivers in some groups were not able to drive all this time because of being under suspension. The average length of time drivers in each group were without their license had to be subtracted from the average post-action period. The value used was not simply the suspension time, but the *actual* time the driver was without his license. For example, in some cases a suspension of three months results in six months without a license because the driver may not be prompt in applying for reinstatement, or he may have trouble filing proof of financial responsibility. The final value, the average length of post-action driving time, was obtained by computing the difference between group means rather than the mean of individual differences.

The actual proportions of drivers violating subsequent to action was corrected to equate for length of post-action driving period. This correction was made by assuming equal proportions violating per unit time. This, of course, is not valid over wide ranges. If ten per cent violate in the year following action, it is not proper to assume that *all* would violate within ten years, because other evidence indicates that most drivers would not violate regardless of the time period. Most cases, however, were sampled over periods of 11 to 15 months with the extreme being only nine to 17 months; therefore, a time correction was made. It was assumed that if 30 per cent of the drivers violated in 15 months, then 24 per cent would have violated in one year. Such a correction is a poor substitute for experimental control of the subsequent driving period, but it is felt that this correction is a lesser evil than unequal time periods.

Finally, it is necessary to discuss one part of the advisory letter research. The data show that approximately 12 per cent of drivers sent letters have further violations, and 19 per cent of drivers not sent letters have further violations. Remember, however, that these are drivers who had a post-action violation but did not reach 12 points. Though it seems far-fetched, the data as presented do not rule out the possibility that the advisory letter makes many drivers *so much worse* that they reach 12 points (and consequently are not in the advisory letter sample). If advisory letters make drivers worse, then it should be true that a greater proportion of drivers with 12 or more points have been sent letters than those with eight but less than 12. Such a test was made, and it was found that the opposite was true to a statistically significant degree, *thus ruling out the possibility that advisory letters make drivers more likely to violate.* More drivers in the eight to 12 point range were sent letters than those in the 12 or more point range. Thus, the effects of the letter remain as indicated—desirable.

Listing of RESEARCH PROJECTS

BELOW is a list of research projects of which the National Safety Council has knowledge. Some of these projects are still in the process of completion, some have been already completed, and some have been recently published.

Each project has been classified by a library classification number, used by the Bureau of Highway Traffic at the Yale University. Each number is a subdivision of a principal heading. The headings are as follows:

000	General	500	Law
100	Road Users	600	Education
200	Vehicles	700	Administration
300	Fixed Facilities	800	Economic and Sociological Aspects
400	Traffic Characteristics and Controls	900	Planning

The title is in quotes, previous publication journals and dates are indicated when known, the name and address of the institution where the research is being conducted follows, with the name of the principal investigator. Cooperating or sponsoring agencies are also mentioned when known. *Short summaries of many of these projects are available, but more complete information can be obtained from the institute or individual doing the research.*

New reports of research will be abstracted and presented in this journal in the earliest possible edition. Each year the March issue will contain a revised listing similar to the one below of all research projects that have been received during the preceding year.

In-Process:

101 "Case Studies of One Car Accidents Involving Young Drivers"—Hwy. Traffic Safety Ctr., Michigan State U., East Lansing, R. W. Bishop, Asst. Professor, Teacher Educ. Ed.D. Thesis, NYU. Apr. 59.

101 "California Accident Repeater Driver Study"—Dept. of Psychol., U. of Southern California, Los Angeles 7, J. P. Guilford, Principal Investigator; D. H. Schuster, Asst. Apr. 58.

101 "The Relationship of Scholastic Achievement to Traffic Citations in the Seattle Public Schools"—U. of Washington, Seattle, M. M. Knoll, Teacher in Driver Educ., Lincoln H. S., Seattle; J. E. Corbally, Adviser. Apr. 59.

101 "An Evaluation of the Road Test Phase of the Driver Licensing Examinations of the Various States"—Center for Safety Educ., NYU, Washington Square, New York 3, F. McGlade. Doctoral dissertation. Jun. 59.

123 "Skill Decrement in Continuous Driving"—Hwy. Traffic Safety Ctr., Michigan State U., East Lansing, A. M. Barch, Asst. Prof. of Psychol; T. W. Forbes, Asst. Dir. for Research. Nov. 58.

130 "Voluntary Medical Questionnaire—Memphis and Shelby County Medical Society"—Memphis Police Dept., Memphis, Tenn., J. C. Legg, Traffic Inspector. Mar. 59.

130 "Investigation into Theoretical Models of the Accident Phenomenon"—Indus. Engrg. Dept., Ohio State U., Columbus, T. H. Rockwell, Asst. Prof. Dec. 56.

130 "Measurement of Safety Performance and Its Use as an Evaluative Tool for Accident Prevention Programs"—Indus. Engrg. Dept., Ohio State U., Columbus, T. H. Rockwell, Asst. Prof. Jun. 58.

131 "A Comparison of Visual Performance of Driver-Educated Trained and Untrained Drivers in Massachusetts"—Mass. Soc. of Optometrists; Mass. Col. of Optometry, 178 New-

bury St., Boston, F. N. Ames, P. Piscia. Sept. 58. O.D. Degree.

131 "Prevalence of Visual Deficiencies in the Driving Population"—Comm. on Motorists' Vision & Hwy. Safety, AOA, 4030 Chouteau Ave., St. Louis 10, Mo., H. W. Hofstetter, Div. of Optometry, Indiana U., Consultant. Jun. 58.

470.1 "Research on Fatal Highway Collisions"—Dept. of Legal Med., Harvard Med. School, Boston, Mass., A. L. Moseley, Research Assoc. Nov. 58.

611.2 "The Measurement of Effective Teaching in Driver Education"—Safety Education Proj., Teachers College, Columbia U., 120 St., New York 27, W. G. Anderson, Research Asst. Sep. 58.

611.2 "Effect of Training on Attitudes, Violations, and Accidents in Adolescent Traffic Violators"—Accident Prevention Program, U. S. Public Health Service, Dept. of Health, Educ. & Welfare, Washington 25, D. C., B. H. Fox. Sep. 57.

611.2 "Relationship Between Performance on the Auto Trainer and Ratings on the Rogers-Lauer Scale"—Safety Engrg. Research Lab., Dept. of Indus. Engrg., Ohio State U., Columbus, W. E. Tarrants. Jul. 58.

640.1 "Relationship of Visual Skills to Driving Performance Among Police Officers"—Indiana U., Bloomington, H. W. Hofstetter, Div. of Optometry; J. A. Mears, Dept. of Police Admin.; B. I. Loft, Dept. of Health & Safety. Dec. 58.

700 "The Political Process in the Auto Sub-Culture: A Research Design in Safety Problems"—Govt. Dept., Grad. Schl. of Arts & Sciences, NYU, Washington Square, New York 17; H. H. Wakeland, Two Tudor City Place, New York 17. Jan. 59. Master's Thesis.

Completed:

101 "Driver Behavior: A Study of Personality Characteristics"—U. of Minnesota, Minneapolis; Safety Div., Minn. Hwy. Dept., P. L. Brown. Masters thesis. Jan. 59.

101 "A Study in the Relationship Between Personality Traits and Driving Behavior"—Safety Div., Minn. Hwy. Dept., P. L. Brown; R. F. Berdie, Dir., Student Counseling Bur., U. of Minn. 1958.

101 "Traffic Accidents and Driver Characteristics: A Statistical and Psychological Study"—*British J. of Indus. Med.*, Vol. 16, No. 2, Apr. 59. British Med. Assn., Tavistock Square, London W. C. 1, England; Institute of Occupational Health, Helsinki; S. Hakkinen, Inst. of Technology, Helsinki, Finland. Apr. 59.

101 "Preliminary Findings from Psychological and Psychophysical Tests Administered in the New Jersey Accident Prevention Clinics"—Drivers Safety Service Inc., 298 Broadway, New York 7, H. L. Henderson, Director of Research. Jan. 59.

101 "The Driving Simulator"—*Police*, 1958. Institute of Transportation and Traffic Engrg., U. of California, Los Angeles, S. F. Hulburt; J. H. Mathewson, Asst. Dir. Reprint No. 65. Apr. 58.

101 "A Criterion Scale for Classification of Automobile Drivers"—Driving Research Lab., Iowa State College, Ames, A. R. Lauer, Director. 1956.

121 "The Age Characteristics of Michigan Drivers"—Hwy. Traffic Safety Ctr., Michigan State U., East Lansing, G. F. King, Asst. Prof., Dept. of Psychol. Oct. 58.

312.2 "An Application of Statistics to Determine the Relationship Between the Frequency of Traffic Accidents and the Width of Paved Shoulders"—Traffic Div., Oregon State Hwy. Dept., Salem, F. B. Crandall, Traffic Engr. Jun. 58.

316.2 "Effectiveness of Symbols for Lane Control Signals"—Hwy. Traffic Safety Ctr., Michigan State U., East Lansing, T. W. Forbes; E. Gervais; T. Allen. Dec. 58. Michigan State Hwy. Dept. Bur. of Public Roads, U. S. Dept. of Commerce. Hwy. Research Board, Annual Mtg., Jan. 59.

316.3 "Driver Needs in Freeway Signing"—Div. of Hwys., California Dept. of Public Works, P. O. Box 1499, Sacramento. Automotive Safety Foundation. Dec. 58.

316.3 "Correlation of Geometric Design and Directional Signing"—Div. of Hwys., California Dept. of Public Works, P. O. Box 1499, Sacramento, G. M. Webb, B. Dentino, R. J. Israel. Jan. 59.

401 "Scientific Aspects of the Road Traffic Problem"—*J. Indian Roads Congress*, Vol. XXII, Part 3, Dec. 57. Central Road Research Inst., New Delhi, India, T. S. Khanna. Paper No. 204.

415 "A Mathematical Model for Highway Traffic"—"En Matematisk Modell For Landsvagstrafik"—Sartryck. Nordisk Matematisk Tidskrift. Band 5. Oslo, Norway, 1957. Dept. of Mathematics, Uppsala U., Uppsala, Sweden, L. Carleson.

415 "Some Geometric Design Considerations for Non-Urban Highways With Mixed Slow and Fast Traffic"—Central Road Research Inst., New Delhi, India, T. S. Khanna, Asst. Dir., Traffic. Aug. 57.

415 "Effect of Bullock Cart on Motor Vehicle Flow on Two-Lane Highways"—Central Road Research Inst., New Delhi, India, T. S. Khanna, Asst. Dir., Traffic. Aug. 57.

422 "Questions and Answers Relating to Speed Limits and Speeds in Iowa"—Iowa Dept. of Public Safety, Des Moines 19, C. O. Swanson, Chief, Research & Statistics. Sep. 58.

432 "Timing of Traffic Signals for Mixed Slow and Fast Traffic"—*Road Research Bulletin*, No. 3, Apr. 57. Central Road Research Inst., New Delhi, India, T. S. Khanna.

436 "Railing Barriers on Busy Road Intersections (Before and After Study)"—*J. Indian Roads Congress*, Vol. XXIII, Part 1, Nov. 58. Central Road Research Inst., New Delhi, India, T. S. Khanna.

460.2 "A Study of Government Office Employees' Transport Problem in New Delhi"—Central Road Research Institute, New Delhi, India, T. S. Khanna, Asst. Dir., Traffic, and Traffic & Transport Consultant, Delhi Administration. Apr. 59.

470 "Effect of Increased Patrol on Accidents, Diversion, and Speed"—Wis. State Patrol; U. S. Bureau of Public Roads; The Traffic Institute, Northwestern U., Evanston, Ill., R. Shumate. 1958. Res. Proj. R 13.

470.3 "Motor Vehicle Accidents — All Facilities — 1st Quarter 1959"—Traffic Engrg. Div., Port of N. Y. Authority, 111 Eighth Ave. at 15 St., New York 11, L. E. Bender, Chief. May 59.

470.3 "An Evaluation of the Effectiveness of Driver Improvement Procedures"—Hwy. Traffic Safety Ctr., Michigan State U., East Lansing, M. W. Chalfant, Schl. of Police Admin.; G. F. King, Dept. of Psychol. Oct. 58. Hwy. Research Board, Annual Mtg., Jan. 59.

470.3 "A Study of Pre-Clinic and Post-Clinic Accident and Violation Records of Drivers Processed by the Accident Prevention Clinics of the State of New Jersey"—Drivers Safety Service Inc., 298 Broadway, New York 7, H. L. Henderson, Director of Research. Mar. 58.

470.3 "Driver Record Study—1958"—Div. of Drivers Licenses, California Dept. of Mtr. Vehicles, P. O. Box 2590, Sacramento 12, I. Samuels, Admin. Analyst. Oct. 58.

511 "A Review of Point Systems with Recommendations for Administration Procedures"—Driver Educ. & Acc. Records Div., N. C. Dept. of Mtr. Vehicles, Raleigh, W. N. Hyde, Director. Dec. 58.

610.1 *"Handbook for Motorists"*—C. Hetschko, Attorney at Law, Frankfurt am Main, Beethovenstr. 51, Germany. Apr. 59.

610.1 "Environment, A Factor in Safety Education"—A. W. Stewart, P. O. Box 1492, Lakeland, Fla. Feb. 59.

610.1 "Safety Education—Beyond Three Dimensions"—A. W. Stewart, P. O. Box 1492, Lakeland, Fla. May. 59.

611.2 "Effects of Training on Driving Performance of Youthful Drivers in Iowa"—Iowa State College Library, Ames; D. H. Soule, Coordinator, Div. of Field Services, Eastern Michigan College, Ypsilanti, Mich. Masters thesis. 1950.

611.21 "Factors of Educational Value for Obtaining Safe Night Driving Speeds"—Research & Statistics, Iowa Dept. of Public Safety, Des Moines 19, C. O. Swanson, Chief; Driving Research Lab., Iowa State College, Ames, A. R. Lauer, Director. Jan. 58.

614.1 "Effect of an Accident Reduction Campaign"—Iowa Dept. of Public Safety, Des Moines, C. O. Swanson, Chief, Research & Statistics; A. R. Lauer, Dir., Driving Research Lab., Iowa State College, Ames. Dec. 58.

813 "What Per Cent of Drivers and Owners of Motor Vehicles Being Operated on Iowa Highways Are Insured in a Manner That Will Comply With the Requirements of the Iowa Financial and Safety Responsibility Act of 1954?"—Iowa Dept. of Public Safety, Des Moines 19, C. O. Swanson, Chief, Research & Statistics. Jan. 59.

844 "Motor Vehicle Accident Characteristics and Analysis"—Iowa Dept. of Public Safety, Des Moines 19, C. O. Swanson, Chief, Research & Statistics. Jan. 59.